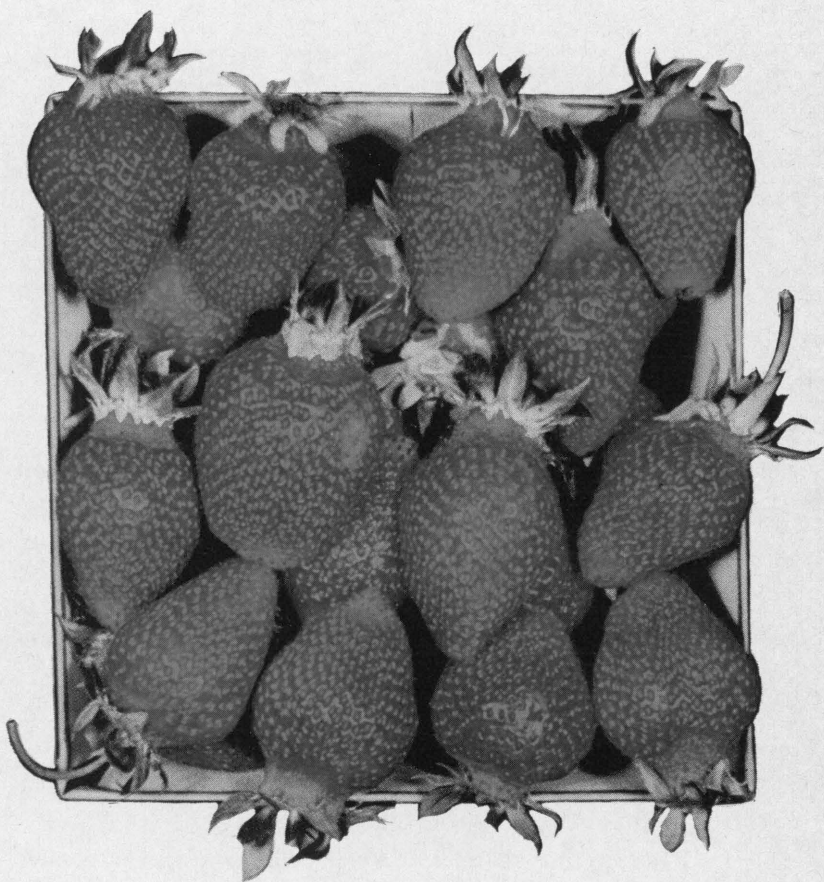


Commercial Production of Strawberries in Illinois

BY CHESTER C. ZYCH AND DWIGHT POWELL



CONTENTS

CULTURE	3	Fertilizers	26
Yields and Costs	3	Before Planting	27
Location	4	During First Growing	
Intercropping	7	Season	29
Varieties	8	After Harvest	29
Soil Management	13	Lime	30
Rotations	15	Mulching	30
Plants and Planting	15	Renovation	32
Obtaining Plants	15	Preventing Spring Frost	
Number of Plants		Injury	34
Needed	16	Harvesting and Handling ...	36
Caring for Plants	16	When and How to Pick ...	36
Setting the Plants	17	Pickers	37
Training Systems	20	Grading	39
Culture During First		Packing	42
Summer	20	"Pick-Your-Own"	
Removing Flowers	20	Strawberries	42
Cultivation	21	CONTROLLING COMMON IN-	
Geese for Weed Control ..	21	SECTS AND DISEASES ...	45
Chemical Weed Control ..	23	Insects	50
Plant Thinning	24	Diseases	55
Irrigation	25		

This circular replaces Circular 819, "Strawberry Growing in Illinois."

COMMERCIAL PRODUCTION OF STRAWBERRIES IN ILLINOIS

By CHESTER C. ZYCH and DWIGHT POWELL¹

PART I—CULTURE²

STRAWBERRIES HAVE BEEN AN IMPORTANT horticultural crop in Illinois for many years. They are grown successfully in all parts of the state either commercially or in home gardens. In comparison with other Illinois fruits, strawberries are exceeded in commercial value only by apples and peaches.

Approximately 2,000 acres of strawberries are grown for market in Illinois. The current center of commercial strawberry production in the state is the Centralia-Irvington area with lesser acreages found in the Cobden-Anna area and in Franklin county around West Frankfort. Additional plantings ranging in size from 1 acre to 40 acres or more are scattered throughout the state, with the heaviest concentrations near the larger towns and cities.

Commercial strawberry production, whether on a small acreage or on 40 acres or more, is not a simple operation. If the enterprise is to be successful, the grower must strive for maximum yields by following good cultural practices.

YIELDS AND COSTS

There are so many circumstances connected with strawberry growing that yields and production costs vary considerably and are hard to appraise. Varieties, soil, climate, location, markets, and the skill of the grower all influence yields and costs.

Many of the better growers harvest 5,000 to 6,000 quarts an acre regularly. Occasionally yields exceeding 10,000 quarts an acre may be obtained under the best conditions, particularly when irrigation is used.

Since production costs per acre are high for strawberries in comparison with the costs of many other crops, yields must be high in order to make substantial profits. Reasonable estimates of the cost from the time the site is chosen to the first harvest range from \$500 to \$700 an acre. The cost of second-year and subsequent crops ranges from \$200

¹ CHESTER C. ZYCH, Associate Professor of Pomology; DWIGHT POWELL, Professor of Plant Pathology.

² Readers specifically interested in the culture of strawberries in the home garden should consult Circular 935, "Growing Small Fruits in the Home Garden."



Sound management practices result in good stands like this, which are necessary to obtain high yields and worthwhile profits. (Fig. 1)

to \$400 an acre. Cost of harvesting and marketing varies greatly with yields and marketing methods. Pick-your-own harvest and marketing costs may be as low as \$100 an acre while conventional harvesting and wholesale sales may run as high as \$1,000 an acre for an 8,000-quart yield.

Successful strawberry growers do not jump in and out of the business. They have some patches in bearing every year and have other patches newly planted for the next year's crop so that over a period of years they have a profitable business.

LOCATION

The prospective commercial strawberry grower should have in mind a few important details about choosing a location, for although the selection of a good location is not a guarantee of success, continued success is seldom obtained without it. A checklist of factors to consider in selecting a suitable location should include market outlets as well as such site characteristics as water and air drainage, amount and direction of slope, soil type, diseases and weeds, and feasibility of irrigation.

Markets. A very important factor to be considered is nearness to a market or some good shipping point. In general, the importance of possible market outlets becomes greater as the size of the planting increases. The larger Illinois towns and cities provide ready markets for strawberries within easy trucking or rail distances. Trucking has become a commonly used means of transporting strawberries during recent years, with service frequently available directly from the strawberry patch. In concentrated production areas, rail service may be used to advantage. However, in order to benefit from carlot shipments, a minimum of 75 to 100 acres conveniently located around the shipping point is required to load one car daily. In some areas, transportation may not be an important factor, particularly where a well-located roadside market provides a convenient and profitable means of disposing of a high-quality crop.

Locations within 15 to 20 miles of large cities are suitable for marketing berries by the "pick-your-own" method. Most growers who have tried this method have been pleased with the results, in some instances receiving more for their fruit than through conventional harvesting methods. Productive, well-cared-for plantings are a must to command premium prices with this type of marketing. (See "'Pick-Your-Own' Strawberries," page 42.)

Sites. Water and air drainage, direction and amount of slope, and soil type are important factors to consider in selecting the site. The greatest advantage to having a site with a little elevation to it is that the slope helps provide water drainage. For although plenty of moisture is desirable, standing water is definitely harmful. Strawberry plants are weakened by being under water for even a few hours. Therefore avoid waterlogged or puddled soils. Such conditions also favor leaching and the development of destructive root diseases. If the only land available is low and poorly drained, grow the plants on slightly raised ridges. Varieties resistant to the red stele disease are preferable under these conditions.

Slope is also a highly desirable feature in a site because it provides air drainage. Cold air, like water, normally flows downhill and collects in low places. Therefore if spring frosts are likely to occur during blossoming, it is an advantage to have a slightly elevated site so that the cold air will drain to a lower spot. A gentle slope falling 2 to 3 feet per hundred is adequate. Other measures, such as mulch or sprinkler irrigation, are necessary to protect the blossoms from a severe or prolonged cold snap. These also make it possible to protect fertile bottom land sites from late spring frosts (see "Preventing Spring Frost Injury," page 34).

The direction of slope should also be considered because of its influence on spring plant growth. Fruit grown on a southern slope

matures as much as nine days before fruit grown on a slope that faces north. However, since the plants on a south slope blossom earlier, there is a greater risk of frost damage to blossoms. Here again, some means of frost protection may be utilized in order to produce early market berries. With such protection available, a grower can plant on both early and late slopes for a longer harvest period.

Since strawberries are cultivated intensively during the first year, gentle slopes are preferable to steep ones. Slopes up to 20 percent are usable by planting on the contour with or without terraces. It is a good practice to plant on the contour on sites with a slope of 5 percent or more (Fig. 2).

The soil factor too is decidedly important because, although strawberries will grow on a wide range of soil types, the best yields are obtained on deep, fertile, well-drained soils of high water-holding capacity. This does not mean, however, that light sandy soils or heavy clay soils are not capable of giving good results when properly managed. Heavy applications of manure or the plowing under of green-manure crops will improve the structure of both types of soils. Sandy soils also require large quantities of commercial fertilizers and the



Sloping sites are desirable for strawberries since they permit good water and air drainage. It is a good practice, however, to plant on the contour on sites with a slope of 5 percent or more. (Fig. 2)

installation of irrigation equipment for maximum yields. Whenever the choice of a site is limited to the less desirable soil types or to newly cleared ground, it is highly desirable to begin soil preparation at least the fall before planting and preferable to begin it a year or two ahead of planting strawberries (see "Soil Management," page 13).

The grower should not overlook diseases and perennial weeds when considering a site for a strawberry planting. If the site is known to be infested with the red stele fungus, only resistant varieties should be planted (see "Varieties," page 8). If the *Verticillium* wilt fungus is known to be present, plant only Surecrop or Sunrise, or consider soil fumigation. Weeds such as bindweed, nutgrass, quackgrass, johnsongrass, and other perennial weeds must be controlled before planting strawberries. Otherwise production costs will be greatly increased and the productive life of the planting may end after the first fruiting season.

INTERCROPPING

Strawberries are sometimes planted as intercrops in young orchards. The berries occupy the land for only a few years and bear fruit the year after planting, thus furnishing an income while the orchard is becoming established. There are objections to this practice: the straw



The strawberries growing in this young peach orchard are a supplement to the grower's income while the trees reach bearing age. (Courtesy J. W. Courter, Department of Horticulture, University of Illinois). (Fig. 3)

mulch is a fire hazard, sometimes harbors mice which may attack the trees, and causes a reduction in the nitrogen available to the trees; orchard operations are more difficult; and cultivation times for the crops differ. If strawberries are used as an intercrop, it is a good practice to plant only a few rows between tree rows (Fig. 3), leaving adequate space on either side of the tree rows to cultivate or disk. Do not set the plants within six feet of the spread of the branches. Then you can cultivate the strawberries late in the fall when the fruit trees shouldn't be cultivated and can cultivate the trees in the spring when the strawberries are still under mulch. Apply extra fertilizers to the trees, use a good mouse-control program, and don't leave the strawberries in longer than two or three harvest seasons.

Intercropping of strawberries with vegetables is not recommended since this practice seldom results in a good planting of strawberries.

VARIETIES

Since the beginning of the commercial strawberry growing industry in the United States in the early 1800's, thousands of strawberry varieties have been named and introduced. New varieties are introduced each year, and some of them seriously challenge the position of the older established varieties. Generally speaking, strawberry varieties are rather exacting in their response to temperature, day length, and soil fertility. Therefore each variety is usually best suited to a particular region. Varieties such as Florida Ninety and Missionary need little or no rest period and are thus adapted to the southern states, whereas most northern varieties require temperatures below 45° F. to break the rest period. The fact that a variety succeeds in a certain area is no assurance that it will thrive elsewhere; even different sites on the same farm may affect the performance of a particular variety.

New varieties are tested at the Illinois Agricultural Experiment Station for their adaptability to some of the different soils and to the different latitudes in the state. However, it is practically impossible to test varieties for their adaptability to all the various soil types found throughout the state. Therefore, growers should test new varieties in small plots (at least 25 plants of each variety) for at least two years to determine adaptability to local environmental and cultural conditions.

When selecting a variety or varieties for the main commercial crop, every grower should keep in mind whether he means to sell on the local market, to ship, or to sell for processing. For local market production, select varieties that have high quality and a long ripening season or else grow several varieties that ripen in succession. Berries to be shipped must be firm enough to withstand the additional handling and transportation. Fruit for processing should be medium and uniform in size, easy to hull, red throughout, and highly flavored.



Testing new varieties and promising selections in small replicated plots is recommended. (Fig. 4)

It is important to include only two or three varieties when strawberries are being raised for the general market since buyers usually prefer to have full carloads or truckloads of the same variety, rather than mixed loads which may differ in firmness or other important characteristics. Larger commercial plantings are usually limited to three varieties that mature in succession, thus extending the harvest season. The use of more than one variety also offers a form of insurance in areas where spring frosts may kill the blossoms of one variety, whereas those of a variety that blooms later may escape injury.

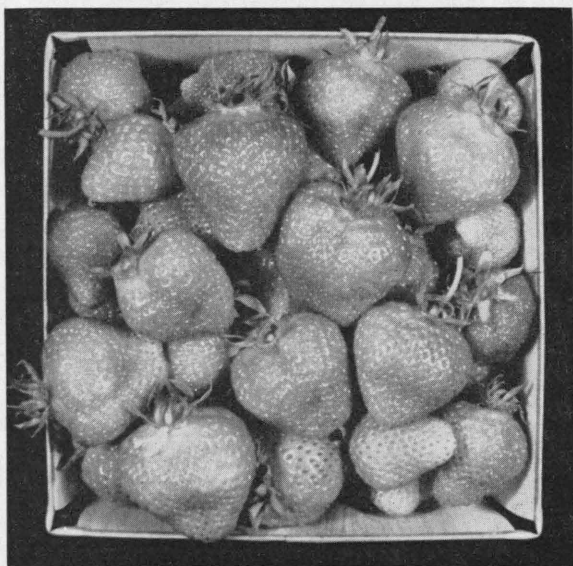
The rise and decline of many commercial varieties may be quite rapid and no variety list remains current for long. Some representative strawberry varieties for commercial production in Illinois are given in Table 1, together with their more important characteristics. By referring to this table and to the discussion of each variety, growers may select varieties generally suited to their area and purpose. Before replacing established, familiar varieties on a large scale, most growers would be wise to try the untested varieties on a limited scale.

Discussion of varieties. The following comments about each variety are intended to supplement Table 1 and should also be considered in the

Table 1. — Characteristics of Strawberry Varieties for Commercial Production in Illinois

Variety	Season (days after Earli- dawn)	Region ¹	Red stele resis- tance	Verticillium wilt resistance	Foliar diseases ²	Fruit size	Fruit firmness	Dessert quality	Process- ing quality for freezing
Earlidawn.....	0	N-S	None	Very susceptible	Susceptible	Medium	Medium	Fair	Very good
Blakemore.....	3	S	None	Some resistance	Resistant	Small	Firm	Fair	Good
Dixieland.....	3	S	None	Very susceptible	Susceptible	Medium	Very firm	Fair	Very good
Sunrise.....	3	N-S	Multiple	Resistant	Susceptible	Medium	Firm	Good	Fair
Surecrop.....	5	N-S	Multiple	Very resistant	Resistant	Medium	Firm	Good	Very good
Pocahontas.....	6	N-S	None	Susceptible	Susceptible	Medium	Medium	Good	Very good
Catskill.....	7	N	None	Some resistance	Resistant	Large	Soft	Good	Poor
Midway.....	10	N-S	Single	Susceptible	Susceptible	Medium	Firm	Good	Very good
Armored.....	10	S	None	Very susceptible	Susceptible	Large	Soft	Good	Poor
Robinson.....	10	N	None	Some resistance	Susceptible	Large	Soft	Fair	Poor
Sparkle.....	12	N	Single	Very susceptible	Susceptible	Medium	Medium	Very good	Very good
Tennessee Beauty.....	12	S	None	Resistant	Susceptible	Medium	Firm	Good	Very good
Jerseybelle.....	14	N-S	None	Very susceptible	Susceptible	Very large	Medium	Fair	Poor

¹ N = northern Illinois; S = southern Illinois.² Leaf spot or leaf scorch; any variety rated susceptible requires control measures.



Earlidawn is a productive early variety on soils of high fertility. It appears to be as blossom-hardy to frosts as Howard Premier. (Fig. 5)

selection of varieties. Following each variety name are the place of origin and date of introduction.

Earlidawn. Maryland, 1956. This is the earliest maturing strawberry variety available commercially and one of the most resistant to spring frosts. A fertile soil and irrigation are needed to initiate and root sufficient runner plants for high yields. New plants should be set 18 inches apart in the row if irrigation is not available. This variety sizes its entire crop well and has a short picking season, maturing about one-half of its crop the first week.

Blakemore. Maryland, 1929. This was the standard commercial variety in southern Illinois for many years and is still planted, though not as widely in recent years because of small fruit size. It is still worth consideration as a shipping berry on good soils with irrigation and plant spacing to improve fruit size.

Dixieland. Maryland, 1953. The fruit of this variety has a tough skin and is very firm, retaining its bright red color and glossy appearance for a considerable time after harvesting. These fruit characters combined with earliness and high productivity on soils free of red stele gained rapid acceptance of Dixieland as the best shipping berry to replace Blakemore in southern Illinois. Unfortunately, the development

of leaf variegation (see page 61) has made the future of this variety uncertain and it is not recommended until variegation-free stocks become available.

Sunrise. Maryland, 1964. This is a new early variety resistant to three races of red stele and fairly resistant to *Verticillium* wilt. The fruit is firm, medium in size, glossy, bright light red, and does not darken after being harvested. Foliage is resistant to leaf scorch and powdery mildew but very susceptible to leaf spot. Matted rows should be narrow and plants well-spaced for maximum production. Sunrise is recommended as an early variety where red stele is a problem.

Surecrop. Maryland, 1956. Surecrop is recommended as a mid-season variety in all types of plantings throughout Illinois. The combination of good average yields, good fruit quality, and resistance to the common root and foliar diseases makes it the most generally reliable variety available to Illinois growers at this time, especially when frost protection is available since the blooms appear to be quite vulnerable to late spring frost injury. The plants are very vigorous and should be limited to narrow rows with plants 6 to 9 inches apart. With irrigation, set plants 30 inches apart in the row in new plantings.

Pocahontas. Maryland, 1953. This variety has produced well in most parts of Illinois where red stele is not a problem and is suitable as an early midseason shipping berry. Some unexplained variability in performance has been observed, particularly in the establishment of new plantings. Growers should check the performance of this variety locally since it is very productive in the right location.

Catskill. New York, 1934. Catskill is recommended for northern Illinois only for local sales and the "pick-your-own" type of operation as a very productive midseason variety. The fruit is usually too soft for shipment. Fruit has the highest Vitamin C content of the varieties listed in Table 1.

Midway. Maryland, 1960. Midway is a late variety resistant to the common race of red stele only. It can be very productive with frequent rainfall or irrigation from bloom to harvest; otherwise medium yields of medium to small berries are produced. Avoid sites infested with *Verticillium* wilt and control foliar diseases.

Armorer. Missouri, 1950. This variety is recommended for southern Illinois only for local sales and "pick-your-own" operations. The fruit is too soft for shipment and the skin color darkens very rapidly after harvest. Control powdery mildew and gray-mold fruit rot.

Robinson. Michigan, 1948. Robinson is a late, large-fruited variety for northern Illinois only. It deserves a qualified recommendation be-

cause of its high productivity of large, furrowed fruit for local sales and "pick-your-own" operations. The fruit is too soft for distant shipment, is only fair for fresh use, and makes a poor frozen pack. Control leaf blight and stem-end fruit rot.

Sparkle. New Jersey, 1942. This is an important late variety for northern Illinois with resistance to the common race of red stele. The fruit is very attractive and of high quality. Berry size tends to run small in later pickings if soil moisture is low during the bloom through harvest period.

Tennessee Beauty. Tennessee, 1943. This is a standard late commercial variety in southern Illinois. The fruit has a green tip and caps easily. Berry size runs small in later pickings without irrigation. Control powery mildew.

Jerseybelle. New Jersey, 1955. The fruit of this variety is large and attractive, but of rather mediocre quality. Premium prices for the fruit may compensate for the relatively low yields obtained under any but the best cultural conditions. The plants are very susceptible to leaf scorch, Verticillium wilt, red stele, and powdery mildew. It is not recommended for general commercial planting but can be profitable as a late variety with close planting on a fertile, disease-free site, with irrigation and control of foliar diseases.

Everbearing varieties are generally not successful in large commercial plantings in Illinois. The specialized system of culture has a high labor requirement and hot weather adversely affects the late summer and fall yields and quality. Fair profits may be possible near cities where a special market situation exists. Detailed information on everbearing varieties and culture is given in Circular 935, "Growing Small Fruits in the Home Garden."

SOIL MANAGEMENT

Land which previously has been in cultivation is to be preferred for a new strawberry planting over land which has been in sod for some years. Growing a cultivated crop for at least one year reduces weed and root-feeding insect problems and improves the physical properties of the soil. However, strawberries should not follow any of the solanaceous crops (potatoes, tomatoes, peppers, or eggplants) because of the susceptibility of these crops to the Verticillium wilt fungus, which may contaminate the soil and seriously damage the strawberries (see page 58).

Serious perennial weeds such as quackgrass, Johnsongrass, nutgrass, and bindweed must be eradicated before strawberries are planted. Con-

sult your county extension adviser about the chemical and cultural eradication programs recommended for such weed problems and begin the program 2 or 3 years before planting to strawberries.

It is recommended that all fields be treated with soil insecticides before planting with strawberries if they have not been treated within three years, because most soil-inhabiting insects are extremely difficult to control after strawberry beds are established. Dieldrin at 2 pounds of the actual material per acre (the percentage of actual insecticide mixed with the carrier is indicated on the container) or chlordane at 6 pounds, actual, per acre are effective against root aphids, white grubs, wireworms, cutworms, and other soil-inhabiting insects. The insecticides should be applied in spray, dust, or granular form to the surface of the soil after plowing, and should immediately be disked into the top 6 inches of soil. Some fertilizer manufacturers are incorporating soil insecticides in their fertilizer mixtures, making it possible to fertilize and apply insecticide in one operation. If such a combination is used, the necessary amount of actual insecticide per acre recommended above should still be applied. Strawberries may be planted any time after the insecticide has been worked into the ground.

The soil should contain abundant quantities of humus (decaying vegetable matter) when the plants are set. This may be supplied either by applying 10 to 30 tons of manure an acre the fall before planting, or by growing and turning under one or more green-manure crops the year before the plants are set. The legume crops — sweet clover, vetch, beans, peas, and, in the southern part of the state, Korean lespedeza — may be used for this purpose. The suggested seeding rates per acre for these crops are as follows: sweet clover, 10 to 12 pounds; vetch, 20 pounds; soybeans, 1½ bushels; cowpeas, 1 bushel; lespedeza, 15 to 20 pounds. A mixture of one of the above summer legumes with a bushel of oats and a peck of buckwheat may also be used. An excellent combination for a light sandy soil is a bushel of rye and 20 pounds of vetch. This combination may be sown as late as August. The fall growth of the vetch and rye may be small, but good growth will begin in the spring. Plow the crop under when the vetch is in full bloom.

Fall plowing is to be preferred over spring plowing unless serious damage from erosion is apt to result. Preparation in the spring may require only leveling with a harrow after the settling effect of the winter. Disking is usually necessary, however, followed by a smoothing harrow and a corrugated roller or a "planker" to break up the clods and to compact the soil before the rows are marked. Where planting on ridges is necessary because of slow drainage, a lister may be used to throw up ridges 3 to 12 inches above the furrows that separate them.

ROTATIONS

Large-scale growers should put strawberries in rotation with other crops for success over a period of years. A good rule to follow is to grow other row crops and green-manure crops for at least as long a period as the strawberries. Some growers have profitably maintained a strawberry planting for 5 years or more but usually plantings are kept for only 2 or 3 harvest seasons, after which the yields become unprofitable because of a reduction in soil fertility and a buildup of diseases, insects, and weeds.

PLANTS AND PLANTING

The health of the runners used for starting a strawberry planting is of vital importance if success is to be achieved. A new planting usually should not be started from an old one because almost all established plantings are heavily infested with virus diseases. In most instances it is far better and cheaper to obtain virus-free plants from a dependable nursery than to risk using plants of doubtful value.¹

Obtaining Plants

Select young plants from an old patch only if they show no evidence of insects or diseases. Clean the soil away from the roots so that insects or other infectious materials are not carried along when the plants are transplanted. Usually growers who wish to use their own stock grow several rows just for that purpose. These rows are kept separate from the main plantings. Inspect such plantings periodically during the growing season to remove any weak or abnormal plants, and when the plants are dug for planting, use only those with large, light-colored root systems and large crowns. Much depends upon the season and the variety, but growers may expect to produce from 6 to 25 good strawberry plants per foot of row.

Growers who feel that the cost and inconvenience of growing and digging their own plants are so great as to make nursery plants more economical should order their plants early, just as soon as the new nursery catalogs are received. Early orders provide a better chance of receiving good plants and a full order. Order only virus-free plants from a reputable nursery, specifying the latest date of shipment for arrival in ample time for earliest possible planting.

¹ Fruit Growing No. 15, "Sources of Small Fruit Plants," may be obtained from the Department of Horticulture, University of Illinois, Urbana 61801.

Table 2. — Number of Plants Needed to Set an Acre
When Spaced at Different Distances

Spacing		Plants to the acre
In the row	Between rows	
<i>feet</i>	<i>feet</i>	<i>number</i>
1	3	14,520
1	3½	12,446
1	4	10,890
1½	3	9,680
1½	3½	8,296
1½	4	7,260
2	3	7,260
2	3½	6,223
2	4	5,445
2½	3	5,810
2½	3½	4,980
2½	4	4,356
3	3	4,840
3	3½	4,148
3	4	3,630

Number of Plants Needed

The number of plants needed to set an acre varies according to how the plants are spaced. In the matted-row system, as used by most Illinois commercial growers, the plants are set 1½ to 2 feet apart in rows 3½ to 4 feet apart (Table 2). The number of plants required to set an acre in other systems may be computed by first determining how many square feet must be allowed per plant and then dividing that figure into 43,560, which is the number of square feet in an acre. Additional plants should be ordered to allow for some discard and for resetting.

Caring for Plants

Treatment of the plants after they are received from a nursery depends upon the time elapsing between arrival and setting and on the storage facilities that are available to the grower. As soon as it arrives the package should be opened and inspected for the condition of the plants and for their variety and number. Any discrepancy should be reported to the nursery immediately.

If setting is planned for the day the package arrives or for the day after, the plants may be stored in a cool place and kept moist. If planting must be delayed for several days, the plants should be placed in cold storage or else heeled in or trenched (Fig. 6) in a well-drained spot



When heeling in strawberry plants, dig a V-shaped trench 6 inches deep. Open the bundles and spread the plants one deep on one side of the trench with the crowns just above the ground as in planting. Cover the roots with soil, firm the soil, and water well. If there is much delay before planting, water when necessary and make sure that the roots are covered to the crown level at all times. (*Courtesy U.S. Department of Agriculture*) (Fig. 6)

which is protected from the sun and wind. Plants stored at 30° to 32° F. in plastic bags or in damp peat moss or sawdust to maintain high humidity grow better than those that have been heeled in. Though temperatures from 30° to 32° F. are best, the range of 30° to 40° F. has been satisfactory. At this point the objective is to maintain the plants in as dormant a condition as possible until planting, avoiding injury from freezing or overheating.

Setting the Plants

Strawberries should be planted as early as possible in the spring. Early planting allows the plants to become well established before hot, dry weather comes. It also produces more early runners, which is desirable because they bear much more fruit than the ones formed later. Fall planting is not a good practice for commercial growers. Fall-set plants require extra care in weed control, and they require mulching to prevent injury from heaving during the winter. Weather and soil

conditions are also more favorable for plant growth in the spring than in the fall. Summer planting trials have not been successful in southern Illinois.

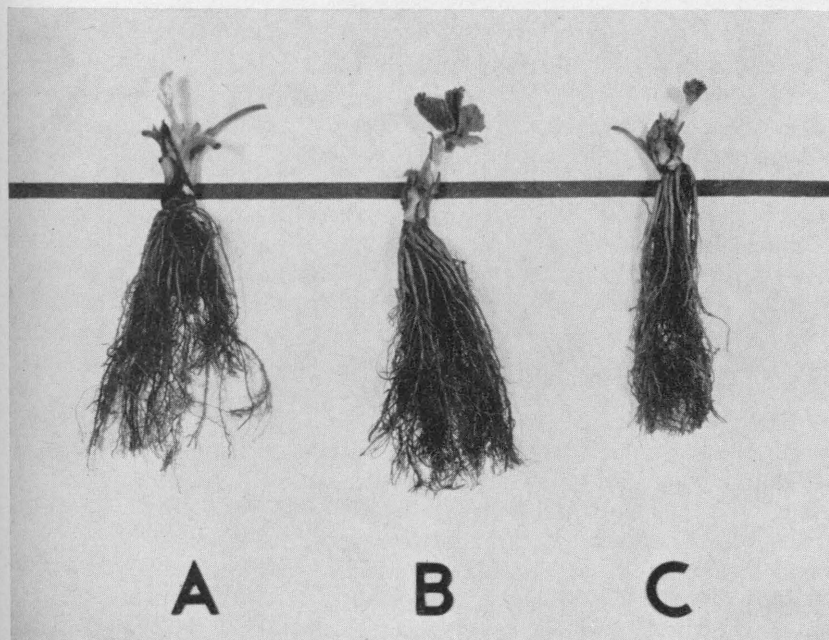
If possible, the plants should be set during cloudy weather or during late afternoon or evening. Every precaution should be used to keep the roots moist while the plants are being handled. Keep the main supply of plants in a shady spot. Also, keep them either wrapped in plastic sheets or in several layers of moist cloth, or keep them stored in partly filled tubs of water. Plants that are being dropped in the row may be carried in a carpenter's apron lined with polyethylene or in a bucket partly filled with water.

The success of a strawberry planting depends largely on the manner in which the plants are set in the ground. Regardless of the method used, two points are of special importance: set the plants at the correct depth and pack the soil firmly around the roots. Strawberries are rather exacting about the depth at which they must be planted. Therefore set them so that the crowns are even with the surface of the ground after the soil has been firmed around the roots (Fig. 7). If the crown is set too shallow it will dry out, and if set too deep it may be smothered. Fan the roots out slightly while inserting the plant into the soil, and pack the soil firmly enough so that a quick upward pull on a leaf stem will result in breaking the stem rather than in uprooting the plant. In order to pack the soil firmly, some growers step on each plant after it is set. If this is done, the instep should be over the crown of the plant to avoid injuring the crown.

Three methods are in common use for setting the plants: (1) machine transplanter; (2) two persons working with a stiff spade or planting bar; and (3) one person dropping plants ahead of setters who each use a trowel or dibble.

On large acreages of comparatively level land, transplanting machines such as those used for tomatoes, cabbages, sweet potatoes, etc., do the setting job quickly and cheaply. An experienced crew can set about 30,000 plants in a 10-hour day, or about 3 to 5 acres. It is advisable to have one man follow the transplanter to reset plants which are not at the right depth or not firmly planted. When set by machine, the plants should be relatively uniform in size and arranged in one direction in the holders. The roots should be straight and trimmed.

Two persons working together with a spade or planting bar can set about 5,000 plants in a 10-hour day. One person handles the spade, jabbing it into the soil about 6 inches deep and pushing it forward to open a hole. The second person carries the plants and inserts them as the holes are made, keeping the crowns at the proper level and the roots slightly fanned out. After the roots are inserted, the first person withdraws the spade and presses the soil firmly about the roots with his foot



Set the plants at the correct depth. Plant A is set at the right depth. Plant B is set too deep, and Plant C too shallow. The soil should just cover the tops of the roots. (Fig. 7)

or inserts the spade again about 3 inches from the plant and pries the soil firmly against the plant. If the soil is so loose and dry that it falls back into the opening before the plant can be placed, the spade may be inserted at a slight angle from the vertical, lifted up, and the plant placed under the spade before it is withdrawn.

Stiff trowels or dibbles may also be used in planting, the procedure being similar to the one just described except that one person both digs and sets, working behind another person who carries and drops the plants. For maximum efficiency, one person should drop plants for two planters.

Watering the plants when setting them may not be necessary if the soil is moist and the plants are in good condition. If the soil is hot and dry, irrigation should immediately follow planting. A transplanting machine has a definite advantage in that it can water the plants as they are set if the soil is dry. On sandy soils, water alone should be used at setting, but on heavier soils, starter solutions are helpful when used on plants set very early in the spring. Mixtures high in phosphorus, such as 10-52-17, 6-25-15, 8-24-8, or 15-30-14, should be used. The solution should be made up and applied as directed by the manufacturer.

Training Systems

The matted-row system of culture is practically the only system used by Illinois growers in commercial plantings. The plants are set 18 to 30 inches apart in rows 3 to 4 feet apart, and the runners are allowed to root at will until the desired width of row is obtained. The width of the matted row varies from 10 to 30 inches, although the intermediate widths (18 to 24 inches) are better. Narrow rows are easier to weed and harvest, produce larger berries, and, since they leave more space between rows, permit better circulation of air between the plants, which reduces the incidence of foliar diseases and fruit rots. Once the rows have reached the desired width, cut off any other runners that develop. A rolling disk attached to the cultivating tool is useful for this purpose.

In the spaced-plant system, the runner plants are arranged by hand until the desired spacing is obtained. Runners formed later are removed as they appear. The final rows are 2 to 2½ feet wide with plants 6 to 12 inches apart in the rows.

In the hill system, all runners are removed so that only the original plant is allowed to grow. This system is used somewhat with ever-bearing varieties and in small home plantings. Plants are set one foot apart in multiple rows one foot apart. The rows are planted in groups of 2, 3, or 4 with about a 2-foot aisle between groups.

Experiments have shown that both the hill system and the spaced-row system will outyield the matted row. However, the matted-row system is adapted to machine farming, and the cost of growing an acre is much lower, thus making the increased yields from the spaced-row and hill systems of questionable value when the grower considers the cost difference against the increase in returns. Furthermore, under conditions of severe drouth or severe winters, a sufficient number of plants in the matted-row system usually survive to give a good stand, whereas the other systems may fail completely.

CULTURE DURING FIRST SUMMER

Removing Flowers

During the first summer after setting, flower stems should be removed as they appear because allowing the fruit to form will seriously reduce the number and size of the daughter plants which bear fruit the following season. The number of trips through the patch to remove most of the fruiting stalks will depend much upon the variety. Those varieties that produce only one cluster per plant will obviously require fewer trips than those that produce several blossom clusters per plant. Usually two or three trips over the patch will be sufficient.

Cultivation

The strawberry has a low habit of growth and is thus not as able as other fruits to compete successfully with weeds for nutrients, moisture, and light. Cultivation should begin as soon as possible after the plants are set. This controls weeds and keeps the soil from getting crusted, thus encouraging the runners to take root. Cultivation should be as frequent as necessary to hold down the weeds but no deeper than 1 or 2 inches near the plants since new roots grow near the top of the crown and are easily cut off. Some growers successfully use a rotary hoe for the first cultivations, before runners are formed. Hoeing will also be necessary to destroy weeds which cannot be reached with a cultivator. Cultivation and hoeing should continue as needed throughout the summer and fall until the first hard frost occurs. Since mulches will protect the late fall weeds as well as the strawberry plants, the planting should be relatively free of weeds before the mulch is applied.

Many types of cultivating machines are now available for strawberries; although they are expensive, they will soon pay for themselves on large acreages. The equipment is designed to reduce the need for hand labor and can also be used for other row crops. Information on self-propelled or sulky-type power hoes, whirlweeder, and rotary-type tillers may be obtained from local implement dealers.

Geese for Weed Control

The use of geese to do the weeding in several crops is not a new idea — cotton farmers have been using them for many years. The geese can kill many weeds in a strawberry planting without damage to the plants. They may be used in a first-year planting until about mid-September, in the spring of the fruiting season up to about 3 weeks before harvest, and after renovation until about mid-September.

The best number of geese to use is 4 or 5 an acre during an average season and 6 to 8 during a wet one. Any breed of geese will be good for weeding, but the heavier geese seem best. Whatever the breed, goslings are the most efficient, beginning when 6 weeks old. They work best when put in a flock with a few old geese.

A fence definitely is needed to keep the geese in the berry patch. If foxes or dogs are a problem, the fence should be of poultry mesh, 4 feet high. Otherwise a 26-inch hog wire fence is adequate. For either type, firm wooden or steel posts should be spaced no more than 15 feet apart. If shade trees aren't available near the patch, a shelter should be provided to protect the geese from the hot sun. The shelter should be located about 40 feet from the patch, if possible, or the geese will trample the plants around it (Fig. 8).



Troublesome weeds may be controlled effectively by properly managed geese. Shelter should be provided outside the field, and food and water at the edges of the patch to avoid excessive damage to the strawberry plants as is evident here. (Fig. 8)

Their weed diet should be supplemented, but not enough to satisfy their appetites or they won't eat the weeds. About a handful of corn per grown goose per day is sufficient, scattered at one end of the patch. Put a 50-gallon container with a drop spigot to drip water continuously into a shallow basin at the other end of the rows. The geese will eat some of the corn, then waddle along the rows to the water, eating weeds as they go. Don't give high-protein feeds to geese. Use a standard feeding ration for goslings for the first 10 weeks, as they rarely eat whole corn. One more point in regard to feeding habits: the geese may not normally eat certain weeds in the patch. If this is the case, it may be wise to pen a few geese and feed them only those weeds for a time. There are some weeds that geese won't eat for any reason, but it is possible to train them to eat certain other weeds in this way and then return them to the patch.

Clipping a few wing feathers will prevent flight. However, never clip the end feathers on the wings since they are needed to hold the wings on the back.

Don't use herbicides if geese are being used for weed control. Most insecticides used in strawberry plantings will not kill the geese, but little is known about what amounts of insecticide residue can be tolerated by them. It may be desirable to remove the geese from the field while insecticides are being applied.

Chemical Weed Control

Chemical weed control in strawberries is still a relatively new practice and the presently available herbicides are not perfect. There are several, however, that can be successfully used in addition to tillage to control weeds in strawberries with a considerable reduction in labor requirements. The technique of coating the roots of strawberry plants with activated charcoal before setting to protect them from herbicide injury holds promise for the expansion of herbicide use in controlling weeds in strawberries.

Because the field of chemical weed control undergoes rapid changes, recommendations for strawberries are annually revised in "Herbicides for Commercial Fruit Crops" available from the Department of Horticulture. The following is a discussion of general precautions applicable to all herbicides and their application to strawberry plantings.

1. *Use only those herbicides that are specifically approved and recommended for strawberries on the label.* Manufacturers sometimes change their labels and government regulations are modified so always consult the most recent product label. At the time of this printing of this circular, sesone, falone, dinitro (DNBP), eptam, 2,4-D, dacthal, CIPC, diphenamid, and chloroxuron (Tenoran) were the only herbicides cleared for use on strawberries under Public Law 518.

2. *Know your weeds.* Selective herbicides are effective on certain weed species only at recommended rates and a particular one may be useless for a specific weed problem (see page 62 for references on weed identification).

3. *Time herbicide applications as directed.* Germinating weed seeds or young seedlings are easiest to kill when conditions are favorable for rapid plant growth.

4. *Know the limitations of the chemicals.* Read the product label for statements such as "Sesone is effective only if it is applied before weed seedlings are more than one-fourth inch high," or "DNBP should not be used in sprayers which have contained copper unless the sprayer is thoroughly cleaned, because the copper will react with the DNBP to form a substance which will clog screens."

5. *Guard against possible injury to nearby sensitive plants.* Use only low-volatile forms of 2,4-D and apply all herbicides on quiet days to avoid wind drift.

6. *Use only recommended amounts.* It is very important to calibrate sprayers carefully to make sure that the right amount of chemical is being applied. A test run should be made over a measured area on the same type of terrain that is to be sprayed. A satisfactory method of calibrating a sprayer is as follows:

- Fill the spray tank with water. If oil or oil emulsions are to be used, the calibration should be made with the complete mixture.
- Spray a measured area at the speed that will be used during the actual application of the herbicide to the strawberry planting.
- Carefully measure the amount of water or complete mixture needed to refill the tank.
- The amount of water or complete mixture used divided by the portion of an acre covered will give the gallons per acre being applied. For example, if 10 gallons of water were applied to $\frac{1}{4}$ acre, the rate would be 40 gallons an acre.
- Mix the amount of herbicide desired for an acre with this much water.

Tractor speed, pressure, nozzle size, and number of nozzles must remain the same or the amount of liquid applied to an acre will be changed and recalibration will be necessary. It is also important to remember that if band applications are used, adjustments must be made for the area actually sprayed.

7. *Observe the pesticide safety precautions given on the back cover of this circular.* Accidents can be prevented if chemicals are handled with respect.

8. *If you are trying out a new chemical or applying one for the first time, learn on a small plot.*

Plant Thinning

A serious defect in the matted-row system of growing strawberries, as used by practically all Illinois commercial growers, is a too-thick stand of plants at the end of a good growing season. This happens the first year as well as during the bearing seasons. Overcrowded plants produce lower yields of smaller berries and provide a good environment for foliar diseases and fruit rots. Although hand spacing of runners in large acreages is generally impractical, some mechanical thinning can be done in the fall. Dump rakes, side-delivery rakes, or spike-toothed harrows may be used to pull up many late-formed runners, leaving the deeply rooted early runners. The object is to pull these excess runners into the area between the matted rows and then cut them off with rolling disks in front of the cultivator shovels, leaving fewer plants in the matted row and still maintaining the desired row width. The plants that are removed would ordinarily bear only a light crop, if any, and would be competition for the more important early-rooted plants.

IRRIGATION¹

The strawberry plant requires large quantities of water because it is shallow-rooted. During most years, irrigation could help many Illinois growers and could save the crop in years when drouth occurs during the period of fruit development and maturation. Other critical periods, when irrigation could insure a good crop for the following year, are: immediately following plant setting, during the period of fruit-bud development, and following renovation (Fig. 9). Supplemental irrigation tests at the Agriculture Experiment Station at Urbana have shown that yields may be increased by as much as 3,000 quarts an acre with the use of sprinkler irrigation during dry seasons.

The most common types of irrigation systems for strawberries are the sprinkler and surface systems. The surface or furrow system can only be used where the soil, or particularly the subsoil, is heavy and where the slopes are uniform and gentle. A sprinkler system has considerable advantage in that it may be used on any type of soil, on level or rolling land, and may also be used as a safeguard for protection of blossoms from frost damage in the spring (see "Preventing Spring Frost Injury," page 34).

The following points should be kept in mind when irrigating strawberries:

1. Strawberries need about 1 inch of water a week during the growing season. If rainfall doesn't supply this amount, make up the difference with irrigation.

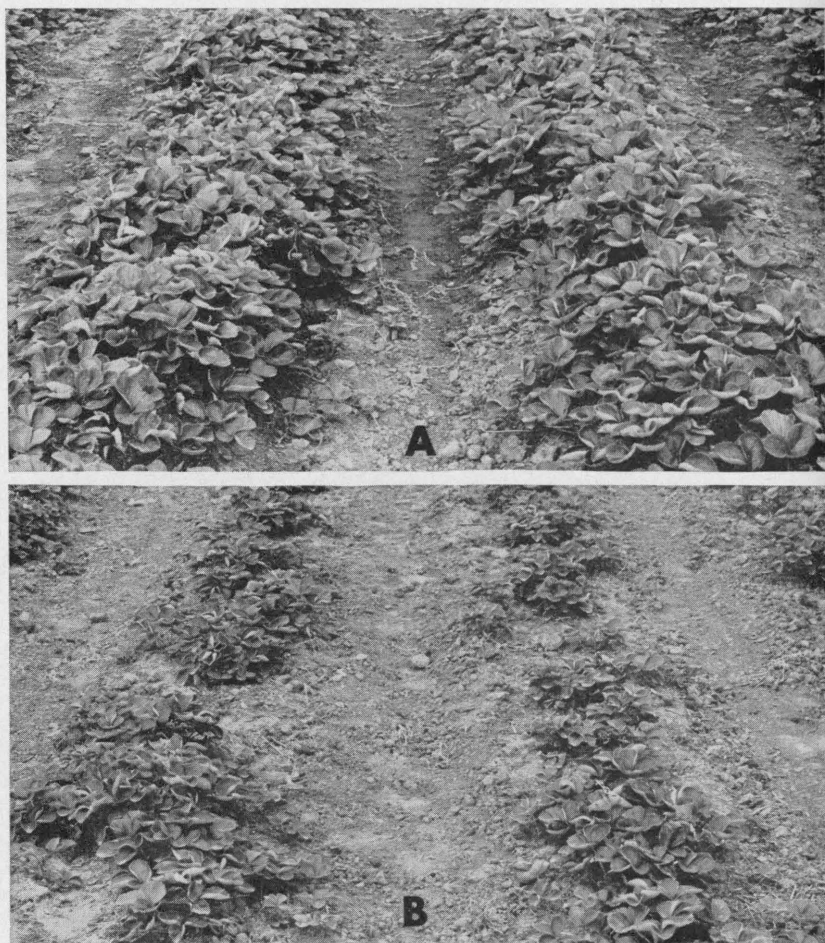
2. Apply water before the plants show symptoms of water deficiency. The time to irrigate may be determined by installing tensiometers or moisture blocks, or by learning to estimate the percentage of moisture in the soil by "feel."

3. Sandy soils require more frequent applications of water, and in smaller amounts, than heavier soils because they hold less available water and excessive irrigation will leach out nutrients beyond the depth of the roots.

4. Apply enough water at any one time to penetrate to a depth of 6 to 10 inches where the bulk of strawberry roots is found. Generally $\frac{1}{2}$ to 1 inch is sufficient for a sandy soil, 1 to $1\frac{1}{2}$ inches for a loam soil, and $1\frac{1}{2}$ to 2 inches for a clay soil. Don't apply the water faster than the soil can absorb it.

5. During the harvest season especially, avoid overwatering or the fruit may be too soft for shipment to distant markets. Maintain an abundant supply of water during the blossoming period and up to the

¹For further information on irrigation methods and systems design, write to the Department of Agricultural Engineering, University of Illinois, Urbana 61801.



Vermilion strawberry plants in September, following harvest and renovation. (A) plots that had received supplemental moisture, (B) plots that had received no supplemental moisture during a relatively dry season. (*Courtesy R. K. Simons, Department of Horticulture, University of Illinois*) (Fig. 9)

time of the development of pink color in the fruits. After this time, irrigate moderately only if a drouth occurs.

FERTILIZERS

Available information on fertilizing strawberries leaves much to be desired, but studies indicate that strawberry plants have nutrient needs similar to those of many other farm crops and that liberal fertil-

ization will prove to be profitable with most plantings in Illinois. The applications of commercial fertilizers to meet these needs should be governed by soil tests, which will give accurate information about the fertility of soils if the soil samples accurately represent the soil in the field. Instructions for getting the soil-testing job done effectively may be obtained from your county extension adviser or from the Soil Testing Laboratory, Department of Agronomy, University of Illinois, Urbana 61801.

The usual times to apply fertilizers to strawberries are before planting, during the growing season for newly set beds, and after harvest when the fruiting beds are to be kept another year.

Before Planting

Soil testing is the best currently available method to use as a basis for preplanting fertilizer recommendations for strawberries, but actual fertilizer requirements for maximum strawberry production in Illinois are not known. However, observations of irrigated plantings on soils of high fertility indicate that high levels of phosphorus and potassium are desirable for maximum yields.

Table 3 is suggested as a guide for treatment of soils following soil tests for phosphorus and potassium. The quantities of each element should be broadcast at least two weeks before planting and disked in well to avoid burning roots of the transplants. This one application prior to setting the plants should provide sufficient phosphorus and potassium for 3 to 4 years, the average productive life of strawberry plantings in Illinois. If the planting is to be maintained longer, soil tests should again be made after the third harvest and the required phosphorus and potassium applied during renovation for the following year.

Nitrogen may also be broadcast before planting at the rate of 40 to 60 pounds of actual nitrogen an acre, but sidedressing 30 pounds of actual nitrogen an acre in two bands about 3 or 4 inches deep and 8 inches from the plants about 2 weeks after planting is more desirable. Band placement doesn't promote weed growth and conserves nitrogen by placing it where it will be utilized by the newly set plants and developing runners.

Other nutrient elements have not yet been reported as limiting factors in Illinois strawberry plantings. Lime needs for strawberries are discussed on page 30. If magnesium or boron deficiencies are suspected, growers should make a special request for inclusion of these elements in the soil analysis and apply needed amounts with the broadcast application of phosphorus and potassium. Apply magnesium at 30 pounds of actual magnesium an acre on soils testing less than 30 pounds and at 15 pounds on soils testing between 30 and 60 pounds an acre. The

Table 3. — A Guide for Preplanting Phosphorus and Potassium Applications When Soil Tests are Made by the Illinois Soil Testing System

PHOSPHORUS		
P ₁ soil test	Applications in pounds an acre	
	P ₂ O ₅	Treble superphosphate
8.....	300	715
12.....	300	715
16.....	300	715
20.....	280	660
24.....	260	620
28.....	240	570
32.....	220	525
36.....	200	475
40.....	180	430
44.....	160	380
48.....	140	335
52.....	120	285
56.....	100	240
60.....	80	190
64.....	60	145
68 and above.....	40	95

POTASSIUM		
K soil test	Applications in pounds an acre	
	K ₂ O	Muriate of potash
40.....	260	435
60.....	240	400
80.....	220	365
100.....	200	335
120.....	200	335
140.....	180	300
160.....	160	265
180.....	140	235
200.....	120	200
220.....	120	200
240.....	100	165
260-320.....	80	135
Above 320.....	0	0

desirable level of boron for strawberry plantings is 2 pounds an acre. If the soil test shows a level of one pound or lower, add one pound of actual boron an acre. Don't exceed the 2-pounds-an-acre level of boron since in excess this element gradually increases in toxicity, killing strawberry plants at the 10-pounds-an-acre level.

During First Growing Season

On the heavier loam and clay soils, apply the sidedressing of 30 pounds of actual nitrogen an acre 2 weeks after planting as described above. Lighter sandy soils should have the sidedressing two weeks after planting and another similar application when the first runners start.

On all soils, a broadcast application of 30 pounds an acre of nitrogen made between August 15 and September 1 is beneficial since it aids in flower-bud formation for next year's crop. Apply the fertilizer when the plants are dry, and brush it off immediately or foliage injury may result. A heavy rope, burlap sacks, or a bundle of fine brush may be dragged over the rows to brush off the fertilizer.

When the above schedule has been followed, no fertilizer should be necessary on the heavier soils until after harvest. Plants growing on such soils should never receive a nitrogen application in the spring of the fruiting year since this practice almost invariably results in heavy foliage, soft berries, increased fruit rot, and delayed fruit maturity.

Sandy soils lose nitrogen rapidly from leaching and should receive an additional application of 30 pounds of actual nitrogen an acre in late winter or very early spring. Very sandy soils will benefit from the addition of 15 pounds of P_2O_5 and 15 pounds of K_2O an acre with the above nitrogen application.

Plantings that have not been adequately fertilized the previous season sometimes indicate a need for nitrogen when the foliage develops in the spring of the fruiting year. Regardless of soil type, a quick response may be obtained by using a urea spray of 5 pounds in 100 gallons of water, applying 200 gallons an acre.

After Harvest

Apply 50 pounds of actual nitrogen an acre to established plantings on heavy soils during renovation (see page 32). This application of nitrogen should be sufficient to provide ample nitrogen through the fruit-bud formation period. If the pre-planting applications of phosphorus and potash were properly made, the need for these elements at this time is questionable. However, analyses of strawberry fruits show that 6,000 quarts of strawberries contain about 10 pounds of P_2O_5 and 27 pounds of K_2O . A maintenance application to replace these quantities may be beneficial.

On sandy soils apply 30 pounds an acre of actual nitrogen, 15 pounds of P_2O_5 , and 30 pounds of K_2O at renovation. Follow with 30 pounds of actual nitrogen an acre in mid-August for flower-bud initiation, and repeat in the late winter or early spring.

LIME

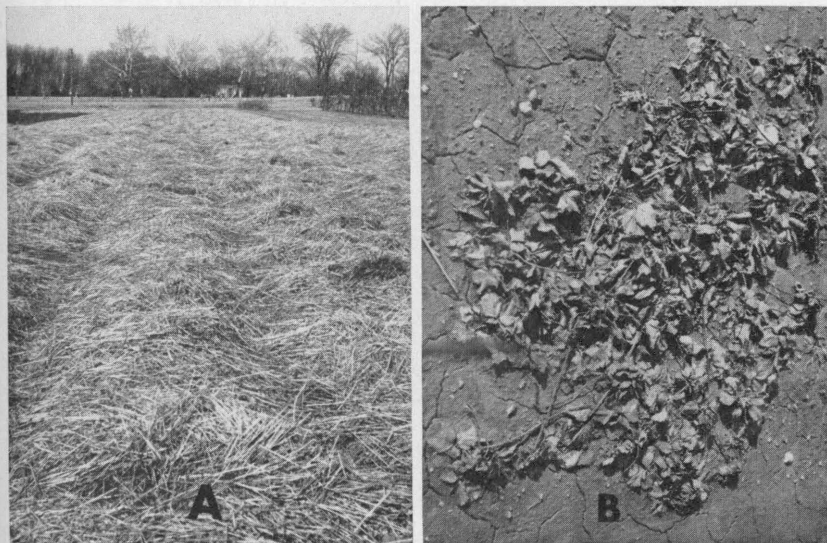
Strawberries generally grow best at a pH of 6.0 to 6.5 but tolerate quite a wide range in pH. No liming should be needed above pH 5.0. Lime should not be applied directly to strawberry plants. It has been shown that an excess of lime dwarfs the plants and reduces the size of the berries. If, however, soil tests show a pH value of less than 5.0, lime should be applied at least 6 months and preferably a year before strawberries are planted. Where the pH is 4.5 to 5.0, use from 1,000 pounds an acre of limestone on light soils to 2,000 pounds on heavy soils. Where the pH is less than 4.5, use from 1,500 pounds on light soils to 3,000 pounds on heavy soils. Use dolomite lime if magnesium is low to medium by soil test.

MULCHING

The principal uses of a mulch on strawberries are to protect the plants during the winter from extreme cold and from heaving, to conserve moisture, to protect flowers from frost, and to provide cleaner berries and better harvest conditions. The value of a mulch in keeping the fruit clean and providing better conditions for the pickers warrants its use throughout Illinois, regardless of other advantages. The two principal disadvantages of mulching are troublesome weed seeds in fresh straw and the greater susceptibility of mulched fields to frosts during blossoming.

Materials and application. Wheat straw is the best material to use (Fig. 10). Pine needles, wild hay, rye straw, oat straw, and wood shavings may be used, but none of these materials is as satisfactory as wheat straw. Do not use any material — such as leaves or shredded corn stalks — that forms a dense layer since it will smother the plants. Apply the mulch after the plants become dormant but before the temperature drops below 20° F. in the fall. This occurs between mid-November and mid-December, depending on what part of the state one lives in and also depending on the year. Mulching machines or manure spreaders may be used on large commercial acreages to spread a uniform layer over the plants. A mulch about 2 inches thick when settled (both over and between the rows) requires about 3 tons of straw to an acre and is sufficient for northern Illinois. In the southern part of the state the winters are milder; so an application of about 1½ to 2 tons an acre is satisfactory.

Weed sprouting may be minimized by using straw one year old. If new baled straw is used, distribute the bales over the patch in early fall and break them open for a thorough rain-soaking. Weed seeds in the



(A) Wheat-straw mulch properly applied for winter protection. (B) Unmulched plants injured by severe cold and heaving. (Fig. 10)

straw then will germinate before it is spread. Stacked straw should be spread 2 to 3 feet deep for soaking and weed sprouting before it is spread over the patch.

Growing a mulch crop between the strawberry rows in early fall is not recommended. The two crops compete with each other for nutrients and moisture to the detriment of the strawberries.

Removal in spring. Leave the mulch on the plants in the spring until the new strawberry leaves under it are slightly yellow, then remove part of it from the rows to the middles. Leave a thin layer for the plants to grow up through. The excess mulch in the middles may be put back on if frost threatens.

Plastic mulch. Black plastic film is being used in commercial strawberry plantings in Florida, Louisiana, and California (Fig. 11). It is effective in keeping down most weeds in the row and in conserving moisture. In some situations it has helped to keep berries clean and has reduced rot. Only the hill system of culture is adapted to its use because the plastic prevents runners from taking root. Cost of the plastic and high labor costs of the single-plant system combined with lower strawberry prices prohibit use of this system by Illinois growers.



Black plastic film used with the single-row hill system.

(Fig. 11)

RENOVATION

What happens to a strawberry planting after harvest has much to do with the following season's crop. The sooner after harvest that the patch is cleaned up, fertilized, and, if possible, irrigated, the better will be the chances of getting a good crop the following year.

Usually a strawberry planting is renovated once or twice and then plowed under, but if a grower has a good site and uses the best cultural practices, plantings may be maintained for longer periods. One planting of the Blakemore variety in southwestern Illinois was maintained in excellent condition through 12 harvest seasons. This is an unusual case and is possible only when the plants are vigorous and when weeds, diseases, and insects are not a problem.

If the soil is fertile and relatively free of weeds and if the plants are vigorous and healthy, it is generally worthwhile to renew the patch. The object of renovation is to destroy most of the plants, saving only enough to re-establish a full stand of new runners for the following season. The following procedure is suggested:

1. Immediately after the last picking, mow the old foliage as close to the ground as possible without injuring the crowns. Rake the leaves and remaining mulch from the patch and burn them if there is a disease or insect problem. If the mulch is not very heavy and the insect and disease problem is not serious, the leaves and mulch may be worked into the soil without raking. Burning over the patch is sometimes practiced,

but it is quite risky. The old foliage, weeds, and mulch must be dry, the ground and crowns of the plants must have a high moisture content, and there must be a good wind blowing to carry the fire rapidly across the patch.

If the soil is very dry and irrigation is available, water the soil after performing step 1. If you can't irrigate and the weather is dry, it may be wise to delay the following steps for as much as 10 days.

2. Top dress with fertilizer as suggested after harvest on page 29.

3. Narrow the beds to 8 to 12 inches. The method used depends on soil type, weather, and equipment available to the grower. Some growers narrow the rows from each side with a cultivator or bar off with a plow, leaving the desired width. Some growers narrow the rows by removing one half of the bed one year and the other half the next. Others "bust out" the middles of the rows each year. A good machine for narrowing the rows is a rotary-type tiller (Fig. 12), which can be adjusted to obtain the desired width of row. U.S. Department of Agriculture findings demonstrate that the original plants can produce good



Renovating a strawberry patch with a rotary-type tiller which may be adjusted for the desired row width. (Fig. 12)

crops for several seasons, so a narrow strip of plants down the center of the row is satisfactory.

4. Clean out the narrowed rows and thin out the remaining plants, preferably by hoeing. Some growers operate a section harrow diagonally across the beds, with the spikes nearly perpendicular, to thin out the plants and cover small weeds. This may be dangerous, especially on hardpan soils where severe use of the harrow may injure the remaining plants and prevent the formation of a full bed for the next season.

5. Apply herbicides if chemical weed control is practiced.

6. If soil moisture is deficient and irrigation is available, irrigate again after the patch has been worked. Strawberries need abundant water at this time to recover from fruiting and to make new plants for the next crop (see "Irrigation," page 25).

7. After renovation, cultivate, control weeds, and if possible, irrigate, as during the maintenance of a first year planting.

If, for any reason, renewing the patch is delayed for much more than 10 days after the last picking, it may be better to just narrow the rows slightly and cultivate thoroughly between the rows. Mowing of fresh, green, active leaves will set the plants back, and severe narrowing of the rows too long after harvest may leave insufficient time for the establishment of new runner plants for the next crop.

PREVENTING SPRING FROST INJURY

Since the strawberry plant grows close to the ground, where the temperature is considerably lower than in the branches of trees, its blossoms are more likely to be killed by frost than are those of fruit trees. On the other hand, since strawberries blossom over a period of three or more weeks, it is unlikely that all of the blossoms will be killed. During most springs in Illinois, late spring frosts will kill some of the blooms in a strawberry planting and these are usually the first flowers that open, the ones which would otherwise develop into the largest berries. The loss of these large, early berries means a real financial loss to the grower.

No strawberry variety is "frost proof," but some are more vulnerable than others. The varieties with long fruit stalks, which elevate the blossoms well above the foliage, are especially susceptible and should be avoided where spring frosts are a danger. Blossoms are most easily injured when they first expand and during fertilization. Light frosts merely injure the point of the cone of pistils, causing the berries to "button." Buttoning, however, may not be due to frost altogether; dry weather, a low nutrient level, or insect injury also cause buttons. The

injury from frost is usually confined to the pistils, which turn black (Fig. 13). The stamens and petals are not injured, and the blossom looks normal unless examined closely.

One practical method of reducing the hazard of frost injury is to select an elevated site for the strawberry planting (see "Sites," page 5). Other methods commonly used are (a) covering the plants with mulch and (b) spray irrigation.

A light covering of mulch will protect against most frosts, but only enough straw should be used to barely cover the plants. If the heavy winter mulch has been left in the middles, it is ready to be used for covering the plants when frost threatens. Since strawberry flowers may be pollinated over a period of several days during cool weather, the mulch may be left on the plants for 2 or 3 days if frosts are expected on successive nights. Sometimes muslin, cheesecloth, or kraft paper is used on smaller plantings.

Portable sprinkler irrigation is especially effective in preventing injury, as is attested by its popularity in Michigan where it is used on



Strawberry blossoms injured by frost. The dark centers are dead pistils. This injury could have been prevented by mulch, sprinkler irrigation, or moving air. (Fig. 13)

over half of the state's strawberry acreage. Frost control with temperatures as low as 22° F., combined with the benefits derived during dry periods in supplying the necessary moisture to mature a satisfactory crop, make sprinkler irrigation systems worthy of consideration by progressive strawberry growers.

A "fogging" effect is obtained by using special frost nozzles with small openings which provide protection against frost injury but do not saturate the soil except during prolonged frost periods. Each grower who installs a spray-type irrigation system will have individual problems concerning what sprinkler types, sizes, pipes, spacing, and pressure to use. Such information may best be obtained from growers with experience or from reliable dealers in irrigation equipment.

In order to be effective during freezing weather, sprinkler systems should be turned on when the temperature at the level of the leaves in the lowest part of the field gets down to 34° F. and should be left on until the freeze is over and all the ice melts. A very accurate and reliable thermometer is essential. Even though the plants may be covered with ice, as long as there is free water on the outside of the ice, the heat that is released as the water cools and freezes will keep the temperature of the plant tissues around 32° F., and there will ordinarily be no injury since tissue damage generally begins at 28° F.

Other methods of frost prevention include large, power-driven fans, smudging, and heating. Wind-making machines are available that will stir the air over approximately 20 acres. Heating and smudging are usually rather expensive methods and are effective only when atmospheric conditions are just right to produce a "layering" effect. Methods utilizing a layer of "foam" are still experimental.

HARVESTING AND HANDLING

The strawberry harvesting season in Illinois usually extends from early May in the southern counties to early July in the northern part of the state. The length of the picking season in any given area varies with the varieties grown and the season. Some varieties pick off in less than 2 weeks while others have picking seasons of 3 or 4 weeks. In a hot, dry year, the picking season will be short, but when the weather is cool with abundant rainfall, picking will continue over a longer period. On the average, the first mature berries appear about 30 days after the first blossoms have fully opened.

When and How to Pick

Berries for local sales and for processing should be harvested when they are fully mature and at the peak of their flavor. If they are to be

shipped, they should be harvested slightly ahead of full maturity in order to be firm enough to stand the handling and not be overripe when they are purchased by the consumer. Generally, berries about three-quarters red are suitable for 24-hour shipment and those with full red color, but firm, for 12-hour shipment. Berries that are harvested when three-quarters red will develop full red color in a day or two at 70° F. and do not differ appreciably in flavor and size from fully red berries. Berries that are harvested when one-half red or less will also develop full red color but will be poorer in flavor and texture and smaller than berries three-quarters red. Thus growers who harvest berries that do not meet the U.S. No. 1 grade for color are sacrificing both quality and size.

The berries should be picked every other day. It may be necessary to pick the same field every day if the weather is hot and berries are maturing rapidly. Picking on rainy days should be avoided because such fruit will not ship well. The best time to pick is early in the day while the berries are cool. If picking continues into the heat of the day and the fruit is to be kept overnight in the packing shed, it is advisable to let the boxes stand uncovered in the shade until they cool. Boxes of warm berries placed in crates as they come from the patch won't cool sufficiently, and frequently the berries in the lower tier of boxes in the crate will arrive on the market in poor condition. Regardless of the time they are picked, strawberries should not be left in the sun after picking, but should be put in a cool place immediately.

When picking berries for the fresh market, leave the caps and about $\frac{1}{2}$ inch of the stem on. This means that the berries should be pinched off by breaking the stem close to the cap, not pulled off. For processing, pick the fruit with the caps off by holding the stem and cap with the fingertips of one hand and pulling the berry off with a slight twist with the fingers of the other hand.

Pickers

For a successful harvest, it is important to have enough pickers, to teach them proper picking, and to supervise them carefully. Having someone to help each picker get started so that he knows what is expected of him can pay dividends by the end of the harvest. Inexperienced pickers should be told how to pick with the most speed and least damage to the fruit and plants, the degree of fruit maturity desired, how to fill the boxes, and what to do with small or rotten berries. A competent foreman must be in charge of the picking crew to see that the fruit is being handled correctly and that the rows are being picked clean. An occasional check by the foreman on a box of berries from

each picker's carrier can contribute much to the over-all quality of the fruit being picked (Fig. 14).

Large growers need to devote some time to recruiting pickers if they are to have enough of them at the proper time. Labor offices, newspaper advertisements, and radio and television announcements may be utilized for this purpose. Some growers keep records of pickers from previous years and send out notices to them in advance of harvest each year. Those growers who depend largely on migrant workers during strawberry harvest should be familiar with the Migrant Labor Camp Law. Information on this subject is available from the Illinois Department of Public Health, Springfield, Illinois 62706.

The number of pickers needed depends upon their efficiency, the seasonal conditions, and the crop yield. Usually 8 to 10 pickers an acre are needed in warm weather and 4 to 6 should keep an acre clean in cool weather.

A simple method of keeping records of the pickers must be followed. Some growers issue numbers to the pickers and keep a record in the packing shed. Others issue tags which may be punched to keep a record of the number of quarts picked, while still others may pay the picker in cash for each box of berries brought to the shed. The pickers are usually paid about one-fifth of the sale price of the fruit. It is a good practice to retain $\frac{1}{2}$ or 1 cent a quart until the harvest is over in order to hold the pickers through the entire harvest season.



The patch foreman can improve the over-all quality of the fruit being picked by an occasional check of a box of berries from each picker's carrier.

(Fig. 14)

Grading

Graded fruit, whether it is for local markets or for shipment to distant markets, sells at a sufficiently higher price than ungraded fruit to return a good premium even after deducting the extra cost of grading. Experienced pickers can satisfactorily grade the berries right in the patch while picking. More commonly, grading is done in packing sheds by carefully pouring the berries from one box to another, discarding the berries that do not meet the grade. Pan grading is a preferred method which involves emptying one box of fruit at a time into a triangular pan, removing all the inferior berries, then pouring the remaining good ones back into the box, always handling the fruit as gently as possible.¹

In the Illinois Standardization Law, now in force, certain grades have been adopted by the State Department of Agriculture governing the sale or offering for sale of strawberries in "closed packages," and the producer is liable for the fulfilment of this law. A crate of strawberries is a closed package in that all its contents cannot be seen readily or inspected after such a package is prepared for market. The United States grades have been adopted in Illinois and are known as the Illinois-U.S. Standards.

The "United States Standards for Grades of Strawberries," as given by the U.S. Department of Agriculture, and in effect since July 1, 1965, are:

Grades

U.S. No. 1 consists of strawberries of one variety or similar varietal characteristics with the cap (calyx) attached, which are firm, not overripe or undeveloped, and which are free from mold or decay and free from damage caused by dirt, moisture, foreign matter, disease, insects, or mechanical or other means. Each strawberry has not less than three-fourths of its surface showing a pink or red color.

(a) *Size*. Unless otherwise specified, the minimum diameter of each strawberry is not less than three-fourths inch.

(b) *Tolerances*. In order to allow for variations incident to proper grading and handling the following tolerances, by volume, are provided as specified:

(1) *For defects*. Not more than 10 percent for strawberries in any lot which fail to meet the requirements of this grade, but not more than one-half of this tolerance, or 5 percent, shall be allowed for defects

¹ A satisfactory pan for grading may be constructed of light sheet metal. The opening at the narrow end of the pan is from 4 to 4½ inches wide, small enough to fit into a berry box. The pan is 10 to 11 inches long and widens toward the top to about 9 inches. The sides are about 1¾ inches high. For a smooth edge, bend back an extra ¼ inch around the three longest sides.

causing serious damage, including therein not more than two-fifths of this latter amount, or 2 percent, for strawberries affected by decay.

(2) *For off-size.* Not more than 5 percent for strawberries in any lot which are below the specified minimum size.

U.S. Combination consists of a combination of U.S. No. 1 and U.S. No. 2 strawberries, except for size: *Provided*, That at least 80 percent, by volume, of the strawberries meet the requirements of U.S. No. 1 grade.

(a) *Size.* Unless otherwise specified, the minimum diameter of each strawberry is not less than three-fourths inch.

(b) *Tolerances.* In order to allow for variations incident to proper grading and handling the following tolerances, by volume, are provided as specified:

(1) *For defects.* Not more than 10 percent for strawberries in any lot which are seriously damaged, including therein not more than one-fifth of this tolerance, or 2 percent, for strawberries affected by decay. No part of any tolerance shall be allowed to reduce for the lot as a whole, the percentage of U.S. No. 1 strawberries required in the combination, and individual containers (cups or baskets) may have not less than 65 percent U.S. No. 1 strawberries: *Provided*, That the entire lot averages within the required percentage.

(2) *For off-size.* Not more than 5 percent of the strawberries in any lot may be below the specified minimum size.

U.S. No. 2 consists of strawberries which are free from decay and free from serious damage caused by dirt, disease, insects, mechanical or other means. Each strawberry has not less than one-half of its surface showing a pink or red color.

(a) *Size.* Unless otherwise specified, the minimum diameter of each strawberry is not less than five-eighths inch.

(b) *Tolerances.* In order to allow for variations incident to proper grading and handling the following tolerances, by volume, are provided as specified:

(1) *For defects.* Not more than 10 percent for strawberries in any lot which are seriously damaged, including therein not more than three-tenths of this tolerance, or 3 percent, for strawberries affected by decay.

(2) *For off-size.* Not more than 5 percent for strawberries in any lot which are below the specified minimum size.

Unclassified

Unclassified consists of strawberries which have not been classified in accordance with any of the foregoing grades. The term "un-

classified" is not a grade within the meaning of these standards but is provided as a designation to show that no grade has been applied to the lot.

Application of tolerances

The contents of individual packages (cups or baskets) in the lot, based on sample inspection, are subject to the following limitations:

(1) For a tolerance of 10 percent or more, individual packages (cups or baskets) in any lot shall have not more than one and one-half times the tolerance specified, except that when the package contains 25 specimens or less, individual packages shall have not more than double the tolerance specified: *Provided*, That the averages for the entire lot are within the tolerances specified for the grade.

(2) For a tolerance of less than 10 percent, individual packages (cups or baskets) in any lot shall have not more than double the tolerance specified, except that at least one defective and one off-size specimen may be permitted in any package: *Provided*, That the averages for the entire lot are within the tolerances specified for the grade.

Definitions

"Overripe" means dead ripe, becoming soft, a condition unfit for shipment and necessitating immediate consumption.

"Undeveloped" means that the berry has not attained a normal shape and development due to frost injury, lack of pollination, insect injury, or other causes. "Button" berries are the most common type of this condition.

"Damage" means any defect or any combination of defects, which materially detracts from the appearance, or the edible or shipping quality of the strawberries.

"Serious damage" means any specific defect described in this section; or an equally objectionable variation of any one of these defects, any other defect, or any combination of defects, which seriously detracts from the appearance, or the edible or shipping quality of the strawberries. The following specific defects shall be considered as serious damage:

- (a) Soft berries;
- (b) Badly deformed berries;
- (c) Badly bruised berries;
- (d) Decayed or leaky berries;
- (e) Berries badly caked with dirt; and,
- (f) Berries with less than one-half of surface showing pink or red color.

"Diameter" means the greatest dimension measured at right angles to a straight line running from the stem to the apex.

Packing

Boxes should be packed so that the berries come slightly above the top and with the corners filled. One-quart veneer boxes are the most widely used. Smaller boxes or those made of plastic or paper have not yet gained general acceptance in the state. Wire-bound or nailed 16-quart wooden crates are used almost exclusively in Illinois. A few growers with special market outlets use 8-quart cardboard crates.

A good way for a grower to establish a reputation with buyers is to have a consistently high-quality pack with his name and the variety grown stamped on each crate.

"PICK-YOUR-OWN" STRAWBERRIES¹

"Pick-your-own" is a specialized method of marketing that means farm-fresh, high-quality strawberries at reasonable prices. Consumers, and especially city people, like driving to the country to harvest their own fruit. They know they are getting the best quality at the lowest prices.

Although the idea of "pick-your-own" strawberries is not new, shortage of suitable labor has forced more growers to try this system. This method is worth consideration by growers in favorable locations as a means of expanding their market and to relieve labor problems. Many growers open their fields to the public after the commercial shipping season is over and the berries are small. This is a "clean-up" procedure and prices are usually reduced in an effort to realize further income. "Pick-your-own" through the entire season may work nicely for operators of roadside markets for other fruits and vegetables as well as strawberries.

There are advantages and disadvantages to "pick-your-own" selling and not all farms or farmers are equally well suited to this type of operation. A discussion of factors that are important for successful "pick-your-own" merchandising follows.

Personality. The grower should enjoy working with the public, be good natured and able to cope with personal peculiarities. He must be willing to work long hours, especially on weekends during harvest time. At times he will have to firmly enforce his "ground rules" and closely supervise the pickers for thorough and efficient harvesting. During harvest, arrangements will have to be made to answer many telephone calls.

Varieties. Grow productive varieties that have large and high-quality berries. Selection of varieties with good freezing quality is im-

¹ This section was prepared in cooperation with J. W. Courter, Assistant Professor of Horticulture, University of Illinois, Dixon Springs Agricultural Center.

portant (see page 8). Two or more varieties, of different maturity, will lengthen the harvest season. Selling by variety name encourages customers to come back for the same variety that they bought and liked last year.

Clean berries. Keep the strawberry field free of weeds and thoroughly mulched. Keep a few extra bales of straw on hand to help in bare spots or in low areas. The plants should be vigorous and healthy. Keep them free of insects and diseases. It takes the best growers to provide optimum picking conditions for the enjoyment of their customers.

Location. Location near large urban communities is desirable. However, customers will often drive 40 or 50 miles to pick their own fruit when none is available closer.

The location of the fields to be harvested is important. If not located on a main highway, signs are needed to direct traffic to the farm and parking area. Each turn should be clearly marked by an arrow. Post low speed limits if customers must drive very far over private, dusty farm roads.

Advertising. Timely and carefully planned advertising is essential. All methods of advertising — signs, newspapers, radio, television, and mail — can be used effectively.

An effective advertising approach is to announce the approximate first harvest date a week or two earlier in newspapers. Then just a day or two before actual harvest utilize a few 10-second radio spots. The short radio spots can be placed quickly by calling the radio studio when more pickers are needed at peak harvest and also to avoid having too many disappointed pickers if there are already too many in the patch.

Post cards are more personal and very effective. Each season you may request the customer to write his name and address on a post card for mailing next season. Following are some advertising ideas that can be printed on the post cards:

- Strawberries are ready to pick now.
- Pick your own at _____ cents a quart, pound, or gallon.
- Quality (variety name) strawberries, excellent for freezing.
- Bring your own containers.
- Boxes for sale in the field for _____ cents each.
- We start picking (day and date).
- The field will open at _____ a.m.
- Picking each day lasts only until acreage set aside for the day has been picked.
- In case of rain, picking will start as soon as rain stops. (If you have the planting properly mulched.)

- Your name, address, telephone number, and directions to the farm.
- Supervised play areas for children.

Large signs advertising "PICK-YOUR-OWN STRAWBERRIES" may be placed along the highway. Some growers also post a blackboard where they can advertise daily picking information such as:

We start picking about May 20.

Next picking: 7:00 a.m., May 22.

Picking arrangements. If pickers are to supply their own baskets and picking containers, make this clear in advertisements. Have plenty of extra cardboard boxes on hand anyway. Some growers find it convenient to loan basket carriers or gallon cans for picking. Selling by the gallon (approximately 3½ quarts) can have some advantages. One successful "pick-your-own" farm in Illinois supplies pickers with gallon cans equipped with a wire handle. The berries are sold at a given price (75 cents to \$1.00 a gallon) and then placed in the customer's pan, dish, or box at check-out time. This keeps all foreign containers out of the patch and permits efficient operation. If cups are used, selling by the pound overcomes the problem of over-filled cups. One quart of strawberries weighs about 1½ pounds.

Parking. Provide adequate parking. An adjacent field, farm lane, or farm lot is often used. Allow space for parking 5 to 10 cars per acre of berries to be picked. If parking is not available near the harvest field, a farm truck or wagon can transport the pickers. This is one way of controlling the pickers but the service should be prompt and courteous. Roadside parking, especially along a busy highway, is not desirable as the congestion is a hazard. Some growers provide only one outlet from the parking area, and collect the fruit charges as the pickers leave.

Field supervision. Planned field arrangement helps in supervision. Picking is best controlled in shorter rows, preferably 200 feet long or shorter. Drive lanes easily divide the field in this manner. Usually some separation occurs when making new plantings.

Pickers should be assigned an area or a section of row to pick. A field supervisor can direct pickers to their assigned areas and instruct on clean picking. Do not allow pickers to do aimless and haphazard picking. The pickers may want to place their berries in the shade while they pick more. Provide such an area.

Prices. The savings in cost of harvesting, containers, and packaging are passed on to the customer. This enables the price to be lower than local retail prices. However, the price need not be drastically lower since the customer appreciates the opportunity for high quality. A South Carolina grower has advertised with the slogan, "Pick-your-own — No extra charge."

Prices may change according to time of season, quality of berries in a given field, and variety. Generally it is advisable to maintain a uniform pricing policy after prices are established. Prices in Illinois have ranged from 20 to 35 cents per quart. Some growers have charged 5 cents more per quart during the first day of harvest. This is when the berries and the crowd may both be the largest.

Some customers will wish to buy more strawberries than they pick. Therefore, growers may have berries picked to keep a supply on hand at the check-out point. Frequently customers want to "pick on the halves" whereby the customer keeps half of the quarts he picks as payment for picking the other half. However, it may be more profitable for the grower to hire pickers at 8 to 10 cents a quart and then sell the berries at retail. Quality control is also easier to maintain with hired pickers.

Insurance. Wise growers carry liability insurance. Unusual claims, such as spider bites, falling, or other accidents, can arise when a large number of people come to the farm.

In summary, the following are prerequisites for successful "pick-your-own" farms:

- Nearness to a sizable population of potential consumers.
- A suitable site.
- Personality to work with the public.
- Adequate parking.
- Courteous supervision.
- Weed-free and pest-free strawberries.
- Good-quality berries for freezing.
- Careful planning in advertising, in field layout, and for traffic control.

Successful "pick-your-own" marketing may be expanded to other fruits and vegetables. Peaches, apples, blueberries, blackberries, corn, beans, pumpkins, and tomatoes are other potential "pick-your-own" crops.

PART II—CONTROLLING COMMON INSECTS AND DISEASES¹

The control of insects and diseases has become increasingly complex, partly because more is being learned about the pests themselves and about what chemicals are needed for their control.² But control is

¹The material on insect control was prepared in cooperation with Roscoe Randell, Extension Entomologist, Illinois State Natural History Survey.

²Growers may keep up to date on chemical controls by writing for the latest *Fruit Leaflet No. 1*, which is published yearly. Write to Department of Plant Pathology, University of Illinois, Urbana, Illinois 61801.

also complicated by other factors. One is the trend toward concentrated production. Pests that usually are readily controlled on small and widely separated plantings become harder to keep down when large acreages are used and the same land is repeatedly planted to strawberries. Another factor is that insects or diseases that have not been common may become so. In case such a pest is one that causes serious damage whenever it does become common, a great deal of harm can be caused very suddenly. In addition to this, during some years the weather in a given locality may entirely cancel out the effect of all the known measures for the control of some pests.

Strawberry growers have placed increasingly great reliance on sprays and dusts and on virus-free nursery stock, but they also regularly employ sanitary and cultural measures. These include using a good site, clean tillage, correct renovation, and suitable, resistant varieties when they are available. If sanitary measures are used alone, infection may become heavy enough within a few years to seriously cut yields. Therefore frequent rotation has always been a standard practice among growers. The more recent controls have not put this practice on the shelf. What they have done is to greatly improve the productivity of the plants while they are bearing and to delay the buildup of the diseases, insects, and viruses that make plowing under necessary. Thus it is most important to integrate control practices.

Chemical controls may help the grower, but he must not overrate their effectiveness. If it rains heavily at a crucial time, for instance, the sprays and dusts may be of little value. Furthermore, chemicals are not always as effective as we would like them to be. Virus diseases are subject to chemical control only insofar as chemicals destroy the insects which carry them. Once such an infection starts, the plant cannot be saved. Some fungi that are directly affected by chemicals are difficult to control because they are hard to reach. For example, some attack the underside of leaves and hence the spray or dust must be applied there. The control of insects and diseases depends upon all the measures named, including rotation. Obviously it also depends upon judgment and vigilance by the grower.

The common insects are the leaf roller, the tarnished plant bug, and the strawberry weevil. In recent years, mites have also become a serious problem and have required special measures for control. Any of the insects discussed in the following pages can become serious. The most common diseases that attack strawberries are leaf scorch, leaf spot, gray mold, and the red stele root rot.

General use of sprays and dusts on established plantings. Many chemicals are used as foliage sprays or dusts for strawberries. They include DDT, TDE, malathion, azinphosmethyl, tetradifon, dicofol,

dodine, and captan. Growers are responsible for any residue found on the fruit in excess of the tolerance. Table 4 shows the specific restriction that applies to each chemical. Some chemicals may be applied only in soil treatment before planting. Others can be used during early bloom, that is before the fruit has formed. Some may be used up to within a few days of harvest, and a few can be used without restriction. Some chemicals may also be used as post-harvest dips.

Before a chemical can be labelled for use, the manufacturer must submit to the U.S. Department of Agriculture documented evidence which substantiates the use claims made. If such claims for use are consistent with limitations and restrictions which have been imposed upon this chemical by the Food and Drug Administration, then a registered label is approved and the material can be marketed. Thus a label should be considered the latest information concerning the use of an agricultural chemical. *Therefore, read the label carefully.*

Spraying with a combination of malathion, DDT, and captan or azinphosmethyl and captan in early bloom, followed by applications of captan at 7- to 10-day intervals, will help a great deal, providing the other controls discussed above have been followed (see Table 5). The early bloom spray controls the strawberry weevil (clipper), the catfacing insects, the gray mold blossom blight, and the leaf diseases. It may be followed up with specific measures, when such are available, if a particular insect or mite infestation or disease breaks out. Dicofol and tetradifon which are acaricides, may be used up to within 2 and 3 days, respectively, of harvest, and captan, a fungicide, may be used practically without restriction. If an insect infestation should develop, then apply malathion again. It is advisable to make close observations to try to spot any insect infestation or disease which may become established.

When making up the combination spray for use during early bloom, it is important to use at least $2\frac{1}{4}$ to 3 pounds of the active ingredient of each formulation per acre with each application. For example, a dust containing 7.5 percent each of captan, DDT, and malathion should be applied at the rate of approximately 30 to 40 pounds an acre. Sprays may be made up from wettable powders. Add 2 pounds each of 50-percent captan, 50-percent DDT, and 25-percent malathion to 100 gallons of water and apply so that 250 to 300 gallons of spray are used an acre for each application. Should the sprayer discharge be such that only 100 gallons an acre can be applied with a once-over treatment, then the required amount of chemical per acre should be mixed with 100 gallons of water. To regulate the amount of chemical used, the volume of spray that the equipment delivers to the acre must be known. This may be determined by first spraying a measured area (see page 24).

Several satisfactory types of sprayers and dusters can be bought. The 3-gallon air-pressure sprayer, which the operator may carry on his

Table 4. — Chemicals Approved for Use on Strawberries in Illinois as of January 1, 1968, Their Residue Tolerance in Parts per Million, and Limitations and Restrictions on Use^a

Chemicals	Residue tolerance	Days restricted before harvest and other limitations
	(<i>p.p.m.</i>)	
Aramite (A) ^b	See label	
Azinphosmethyl (Guthion) (I).....	2.0	5 days of harvest
Barium fluosilicate (I).....	See label	
Beta-naphthoxyacetic acid (GR)....	50.0	14 days of harvest
BHC (I).....	5.0	Use only before edible parts start to form
Bordeaux mixture (F).....	exempt	No time limitations
Botran (F) (See dicloran)		
3-bromopropyne (ST).....	25.0	2-3 weeks before planting
Calcium arsenate (I).....	3.5	Bait. Do not apply to foliage
Captan (F).....	100.0	No time limitations
Carbophenothion (Trithion) (I)....	0.8	5 days of harvest
Carbaryl (Sevin) (I).....	10.0	1 day of harvest
Chlordane (I).....	0.3	Preplanting soil treatment only
Chloropicrin (ST).....	See label	
Chloroxuron (Tenoran) (H).....	0.1	60 days of harvest. See label
CIPC (Chloro-IPC) (H).....	See label	Dormant only
Copper sulfate (F).....	exempt	No time limitations
Cryolite (I).....	7.0	See label
Cuprous oxide (F).....	exempt	Only prebloom and postharvest
2,4-D (H).....	See label	
DCPA (Dacthal) (H).....	2.0	Only prebloom
D-D mixture (ST).....	See label	
2,4-DEP (Falone).....	See label	
DDT (I).....	7.0	See label
Demeton (I).....	0.75	21 days of harvest
Diazinon (I).....	0.75	5 days of harvest
Dibrom (see naled)		
Dichlone (F).....	15.0	3 days of harvest
Dichloropropene (Telone) (ST)....	See label	
Dicloran (Botran) (F).....	15.0	No time limitations
Dicofol (Kelthane) (A).....	5.0	2 days of harvest
Diphenamid (H).....	1.0	See label
Dieldrin (I).....	0.1	Only preplanting treatment
Dinocap (Karathane) (F).....	See label	
DNAP (H).....	See label	
DNAP-DNBP mixture (H).....	See label	
DNBP (H).....	See label	
Dodine (Cyprex) (F).....	5.0	14 days of harvest
Dyrene (F).....	10.0	5 days of harvest
Endosulfan (Thiodan) (I).....	2.0	4 days of harvest. See label
Endrin (I).....	See label	
EPTC (Eptam) (ST).....	See label	
Ethion (I).....	2.0	2 days of harvest
Ethylene dibromide (ST).....	5.0	3 weeks before planting
Ferbam (F).....	7.0	14 days of harvest
Folpet (Phaltan) (F).....	50.0	No time limitations
Guthion (I) see azinphosmethyl		

^a Compiled from information obtained from the Pesticide Regulation Branch of the Agricultural Research Service, USDA.

^b A = acaricide; F = fungicide; GR = growth regulator; H = herbicide; I = insecticide; ST = soil treatment.

Table 4. — (concluded)

Chemicals	Residue tolerance	Days restricted before harvest and other limitations
	<i>(p.p.m.)</i>	
IPC (Isopropyl N-phenyl carbamate) (H).....	See label	
Karathane (F) see dinocap		
Kelthane (A) see dicofol		
Lead arsenate (I).....	7.0	Use only before edible parts form
Lindane (I).....	10.0	Use only before edible parts form
Malathion (I).....	8.0	3 days of harvest
Maleic hydrazide (GR).....	See label	
Metaldehyde (I).....	See label	
Methoxychlor (I).....	14.0	14 days of harvest
Methyl bromide (I)(F)(ST).....	25.0	Fumigant — see label
Methylene chloride (F).....	exempt	Post-harvest fumigant. See label
Methyl parathion (I).....	1.0	14 days of harvest
Nabam VI with zinc sulfate (F)....	7.0	7 days of harvest
Naled (Dibrom)(I)(A).....	1.0	4 days of harvest
Nicotine sulfate (I).....	2.0	No time limitations
Ovex (A).....	See label	
Parathion (I).....	1.0	14 days of harvest
Paris green bran bait (I).....	3.5	See label
Phaltan, see folpet		
Piperonyl butoxide (I).....	exempt	No time limitations
Potassium cyanate (ST).....	See label	
Pyrethrins (I).....	exempt	No time limitations
Rotenone (I).....	exempt	No time limitations
Sabadilla (I).....	exempt	No time limitations
Sesone (H).....	2.0	7 days of harvest
Sevin, see carbaryl		
Sodium arsenite bait (I).....	See label	
Sodium fluosilicate bait (I).....	See label	
Sulfur (F).....	exempt	No time limitations
TDE (I).....	7.0	5 days of harvest
Tenoran, see chloroxuron		
TEPP (A).....	See label	
Tetradifon (Tedion) (A).....	5.0	3 days of harvest. See label
Thiodan, see endosulfan		
Thiram (F).....	7.0	3 days of harvest. See label
Toxaphene (I).....	7.0	Not after fruit begins to form
Trithion, see carbonphenthion		
VC-13 (H).....	See label	
Zineb (F).....	7.0	7 days of harvest
Ziram (F).....	7.0	7 days of harvest. See label

WARNING STATEMENT. At the time this publication was assembled certain pesticides were registered on a “no residue” or “zero tolerance” basis. After December 31, 1967 registration under the Federal Insecticide, Fungicide, and Rodenticide Act requires finite tolerances or exemptions from tolerance requirement. When the status of a material is uncertain the caution “see label” is given.

Table 5. — Insect and Disease Control Spray Schedule

To control	When to apply	Material	Amount	
			per acre	per 1,000 sq. ft.
Weevil, catfacing insects, spittlebug, leaf scorch, leaf spot, gray mold, blossom blight	At first appearance of blossoms	DDT 50W plus malathion 25W	3 lb.	6 tbsp.
		or azinphosmethyl (Guthion) 50W	4 lb.	6 tbsp.
		plus either dodine 65W	2 lb.	4 tbsp.
		or captan 50W	2 lb.	5 tbsp.
			6 lb.	8 tbsp.
Leaf scorch, leaf spot, gray mold, blossom blight, fruit rot	7 to 10 days after Spray No. 2; re- peat every 7 to 10 days until harvest	Captan 50W	6 lb.	8 tbsp.
Leaf roller	When needed after bloom	TDE 50W	4 lb.	8 tbsp.
		or malathion 25W	8 lb.	10 tbsp.
Mites	When needed after bloom	Dicofol (Kelthane) 35W	3 lb.	7 tbsp.
		or tetradifon (Tedion) 25W	2 lb.	3 tbsp.
Leaf diseases and aphids	10 to 14 days after renovation	Malathion 25W	8 lb.	10 tbsp.
		plus either ferbam 76W	3 lb.	10 tbsp.
		or dodine 65W	2 lb.	5 tbsp.

See also: Limitations on use of chemicals (Table 4).

When spraying strawberries use plenty of water, preferably 100 to 300 gallons per acre for each application. This assures good coverage. Dusts may be substituted for sprays, and when applied during periods of wet foliage are more effective than sprays. Read the labels carefully for amounts to apply.

shoulder or at his side, is well suited to the small patch. Small hand dusters are quite efficient. On larger plantings use a power sprayer or duster made especially for use in small fruit and vegetable growing. *Clean equipment carefully after use.*

INSECTS

Since insect control partly depends on the grower's being able to identify the insects which cause trouble, the authors suggest the following reference work: *Destructive and Useful Insects*, fourth edition,

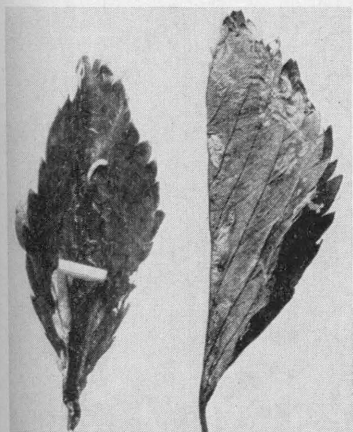
by C. L. Metcalf, W. P. Flint, and R. L. Metcalf (McGraw-Hill Publishing Co., New York, 1962.) USDA Farmers' Bulletin No. 2184, "Strawberry Insects," also contains helpful information for growers. (See page 62.)

White grub. The white grub is the immature, or larval, stage of the June bug or May beetle. This insect lives and feeds in the ground for one to three years in the larval state. If the patch has been in sod just before planting, this grub may be in the soil and will attack the roots and crowns of the plants. For information on preparing the soil for planting, see the section on soil management, page 13. If such preparations are not made, grubs may destroy the patch the first year since they are difficult to control after the plants are set.

Strawberry leaf roller. The strawberry leaf roller is a small, greenish-brown caterpillar with a brown head. As its name indicates, it rolls one portion of the leaf over upon the other and feeds within this protecting fold (Fig. 15). It is very active when disturbed.

Normally the leaf roller is not a serious problem and can be adequately controlled by malathion as recommended on page 46. If it develops despite the malathion, apply TDE at 5 pounds actual per acre in either dust or spray (see Table 4). TDE is specifically effective against this insect.

Strawberry flea beetle. The strawberry flea beetle is a small, brown or black, oval-shaped beetle about $\frac{1}{8}$ inch long. Most of the damage is done by the mature form of the insect. The adult beetles riddle the leaves with "shot holes," beginning their work as soon as plant growth



Right — A leaf typically folded by the strawberry leaf roller. Left — The same leaf held open to show the larva. (Courtesy Missouri Agricultural Experiment Station) (Fig. 15)

commences in the spring. A second generation matures late in the summer and again injures the plants seriously.

Control is effected by spraying or dusting with malathion as recommended on page 46. Since the mature beetles hibernate in waste-land, such cover near strawberry beds should be burned over during the winter or early spring if this pest continues to be serious. Old strawberry plantings nearby should also be kept clean. This is especially important in large plantings.

Tarnished plant bug and stink bug. The adult tarnished plant bug is about $\frac{1}{5}$ inch long and colored an inconspicuous dull yellow or green, mottled with reddish brown. The group of insects called the stink bugs is composed of many different species, most of which are rather general plant feeders. Many of them infest strawberry plantings. The different species of stink bugs vary from $\frac{1}{2}$ to $\frac{3}{4}$ inch long. Their coloring varies from a light green to a light brown. Both the tarnished plant bug and the stink bugs have a wide range of food plants and are responsible for most of the catfacing on peaches. The adults puncture young strawberry fruits, causing them to develop unevenly, especially at the tip. These berries are called "buttons."

The spray or dust mixture recommended on page 50 for early bloom will reduce injury as much as 50 to 75 percent.

Strawberry weevil or "clipper." The strawberry weevil, a small, reddish-brown snout beetle, about $\frac{1}{10}$ inch long, appears just as the strawberry begins to blossom. The female beetle punctures the bud and deposits an egg within it. She then girdles the fruiting stalk below the injured bud, causing it to droop and fall.

The spray or dust combination recommended on page 50 for use during early bloom has been effective in controlling this insect.

Strawberry crown girdler or root weevil. Reports of damage by this insect have come from southern and western Illinois. Injury is caused mostly by the small, white, legless grubs, which emerge from their hibernating places near the roots of the strawberry plants as warm weather approaches, and begin to feed on the crowns. At the same time, the beetles gather in the patch and egg laying begins on the roots of the plants. The beetles cannot fly, as their wing covers are grown together. The eggs soon hatch into grubs. There may be two broods a year in Illinois.

For chemical control, use the spray or dust mixture recommended on page 50 for use during early bloom. Control also depends on adequate preparation of the soil (see page 13).

Strawberry crown borer. Outbreaks of the strawberry crown borer, an insect native to the upper Mississippi valley, occur occasionally in



These strawberry crowns have been seriously damaged by strawberry crown borers. (Courtesy Illinois Natural History Survey) (Fig. 16)

widely scattered sections of Illinois and result in considerable damage. Most of the injury is caused by the white, thick-bodied grubs, which are about $\frac{1}{5}$ inch long when full grown. The adult is a reddish-brown snout beetle about $\frac{1}{6}$ inch long, which hibernates in the soil or under litter in or near the patch. In early spring, eggs are laid in the plant near the surface of the ground. Egg laying may continue up to nearly the end of June. On hatching, the grub works down through the crown, and by maturity may have eaten out most of the contents (Fig. 16). Sometimes only the shell is left if several grubs have been at work on one plant. After maturity in midsummer, the grubs transform to beetles, which remain in the burrows in the plant crown for several weeks before they eat their way out. The beetles go into hibernation when winter approaches. Only one brood is produced each year. Infested plants are so weakened that they either die or produce very little new runner growth.

If any borer damage occurs, the use of insecticides as suggested on page 50 during the early spring may have an effect in reducing the

population of the adult beetles. If an infestation develops, do not allow the bed to fruit more than two years.

New plantings should be no nearer than 350 yards from old beds, for the beetles crawl as far as 300 yards. They do not fly because their wing covers are grown together. Keep cinquefoil (or fivefinger) weed, on which these insects also live, from growing near strawberries.

Strawberry rootworm. Grubs of several species of small, copper-colored beetles, often very abundant in older beds, feed on strawberry roots. The adults feed on the foliage. The general spray suggested on page 50 for use during early bloom may help control this insect.

Strawberry root aphid. Dark bluish-green aphids hatch from shining black eggs on the leaves and stems of the strawberry plant early in the spring. They are often found by the brown cornfield ant and carried down to the strawberry roots, where they feed on the plant sap. Infested plants lose vigor, and their berries do not mature properly.

The general use of insecticides as suggested on page 46 will help control this insect. When setting out a new bed on the same ground where a root aphid infestation has occurred, follow the preplanting recommendations given on page 14.

Cutworms. When strawberry plants have been cut off at or below the surface of the ground early in spring, the damage may have been caused by cutworms. These insects are small, smooth, ground-colored caterpillars about an inch long. They hide just below the surface of the ground during the day and forage at night. There are at least a hundred different species of cutworms in Illinois, but most of them can be killed through the use of a poison bran bait.

Poison bran bait. — A formula for poison bran bait suitable for use on a small strawberry patch is 1 quart of bran or middlings, 1 teaspoonful of paris green, and 1 tablespoonful of cheap molasses, with sufficient water to moisten the bran. When injury from cutworms is severe, quicker results are possible if the poison mixture is made sweeter by doubling the amount of molasses. Scatter the bran evenly over the patch just at dusk and do not put it in lumps or windrows.

Directions for mixing and for using this mixture on a large scale are as follows: Add 2 quarts of blackstrap or other cheap molasses to 3 gallons of water and mix thoroughly. Stir in 1 pound of paris green, and add 25 pounds of bran, mixing the bran with the water and molasses until all of it has been moistened. If the mash is sloppy, add more bran until it is just thick enough to hold together when tightly squeezed in the hand. This mixture should be scattered over infested fields at the rate of about 8 to 10 pounds an acre.

The use of the insecticides recommended on page 50 will also help control cutworms.

Spittlebugs. White, frothy, irregular masses $\frac{1}{2}$ inch or more in diameter covering small green insects sometimes appear on the stems and leaves of strawberries. The insects are known as spittlebugs because of their peculiar spittle-like covering.

The insects live over winter in the egg stage. The nymphs appear in April or May and complete their development in 5 to 8 weeks. Only one generation occurs each year. The eggs are laid during the fall months. This insect has never been serious in Illinois but is present and commonly observed. The early-bloom insecticide spray probably helps to kill the young nymphs before they have a chance to protect themselves. Endosulfan 50W, at 1 lb. an acre, is particularly effective in controlling these insects. Once the spittle is formed, the insects are difficult to reach.

Spider mites. Several species of mites attack strawberry plants. Since the chlorinated hydrocarbon insecticides have come into use, many of the natural enemies of mites have been destroyed, and they have become serious in many plantings. Mites are quite small, measuring approximately $\frac{1}{50}$ inch in length. In color they vary from pale greenish-yellow to dark crimson, sometimes marked with dark spots, one on each side of the body. They can be clearly seen with a magnifying glass. The length of the life-cycle varies with temperature, but normally a new generation is produced every 2 weeks. Mites cause a bronzing of the foliage, which eventually turns yellow with rusty brown blotches. Plants are stunted and yield may be greatly reduced.

When mites need control, use either dicofol or tetradifon with the regular insecticide and fungicide applications.

Snails and slugs. There are many species of snails and slugs that may be troublesome in strawberry plantings, particularly during wet seasons. Both feed on the foliage and fruit at night and hide in the soil or damp refuse during the day. They eat out large, irregular areas in the foliage and fruit and leave a glistening trail of slime. Control with a commercial bait containing 2 to 3 percent metaldehyde and 5 percent calcium arsenate according to directions on the container.

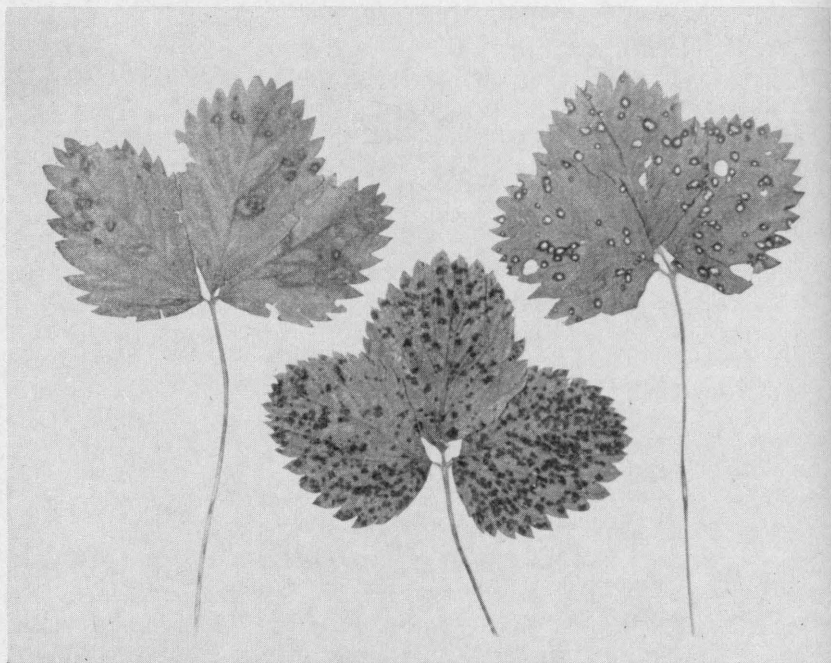
DISEASES

Many diseases interfere with the normal development of strawberry plants. A grower should attempt to study these diseases so that he can recognize them if they do occur. Space in this circular does not permit detailed discussions of the various diseases, but for further information see *Diseases of Fruit Crops* by H. W. Anderson (McGraw-Hill Publishing Co., New York, 1956). USDA Farmers' Bulletin No. 2140, "Strawberry Diseases," also contains helpful information for growers. (See page 62.)

Strawberry leaf diseases. Three leaf diseases can cause severe damage to strawberries in Illinois when climatic conditions favor their development: leaf spot, leaf scorch, and leaf blight. Each may appear alone or with the others on a leaf or plant and each may greatly reduce plant vigor and yield.

Strawberry leaf spot is caused by a fungus known as *Mycosphaerella fragariae*. It infects the leaves, petioles, fruit, and pedicels, but is serious mainly on the leaves, causing a circular white spot with a purplish border (Fig. 17). Cool, wet weather favors this disease. It may then cause fruits to be abnormal and show a black seed condition.

Leaf scorch is caused by a fungus known as *Diplocarpon earliana*. It is primarily a leaf disease but may also infect the calyces, petioles, and pedicels. In the early stages of infection, small purple spots appear on the upper surface of the leaves (Fig. 17). Each spot may enlarge until it resembles a slight spot of tar. Finally the spots coalesce, covering the entire leaf. This disease may develop from early spring until



Leaf symptoms of three strawberry diseases. Left, leaf blight; center, leaf scorch; and right, leaf spot.

(Fig. 17)

late fall whenever moisture is available. It is now considered the most serious strawberry leaf disease in Illinois.

Leaf blight is caused by a fungus known as *Dendrophoma obscurans*. It is as common as the two leaf diseases just discussed but normally does not do as much damage. It infects primarily the leaves and calyces and during wet, warm weather may cause a stem-end rot of the fruit.

Leaf blight looks distinctly different from leaf spot or leaf scorch (Fig. 17). A typical spot is at first purple but later develops into a dark-brown center encircled by a light-brown area, which, in turn, is surrounded by a purple ring. A V-shaped infection is most common, with the wide part of the V at the leaf margin. Except on very susceptible varieties this disease does not appear until early summer. In Illinois it is primarily of importance on either new or renovated plants as they are developing during the summer and fall period.

Control of the leaf diseases is quite difficult. Both scorch and spot infect only the underside of the leaf; thus sprays or dusts (see page 46 and Table 5) must be applied to this surface for effectiveness. In addition, none of the commercial fungicides is sufficiently effective to control these diseases when conditions are ideal for infection.

Red stele root rot. This is a root rot caused by the fungus *Phytophthora fragariae*. It is a serious disease of strawberries since most of the desirable commercial varieties are highly susceptible to it. The symptoms first appear in the spring from about full bloom to the harvest period. The leaves become somewhat rolled and wilted at first. As the disease progresses, the leaves take on a dull leaden cast in contrast to the normal bright-green color of healthy leaves, the plants become stunted, and the fruits dry up. Infected roots show a browning or reddening of the stele, or central core. The root tips usually die, and only a few of the small rootlets develop as compared with a normal plant (Fig. 18).

In a cool, wet spring, red stele may appear to be fairly well distributed over the entire strawberry patch. Normally, however, it is prevalent only in the lower or poorly drained areas of the field. Usually when plants start wilting and dying in the lower portions of the strawberry patch, the disease is red stele.

To minimize red stele, plant disease-free stock, preferably of resistant varieties, and avoid poorly drained sites (see page 5) and contaminated soils. Once the fungus is established in the soil, it may remain viable for at least 12 years regardless of which crop rotation is used.

The only practical method of controlling red stele that has been found so far is the use of resistant varieties. A number of resistant



Symptoms of red stele root rot. Left—plant on left showing effects of the disease. Note the stunted appearance of the plant and the absence of small feeding roots as compared with the normal plant on the right. Center and right—strawberry roots cut lengthwise to expose the central core or stele. Healthy root on the right with light-colored stele and infected root in the center with reddened stele.

(Fig. 18)

varieties have been developed (see Table 1, page 10).¹ The fungus causing red stele has been found to have different races and these races differ in their ability to infect different varieties. A variety that is resistant to red stele in one area may therefore be susceptible in another. For practical purposes, Illinois strawberry growers should be concerned about only the common or A-1 race. Race A-3 has also been found in Illinois and its distribution is now believed to be extensive.

Verticillium wilt. This is a vascular disease caused by the fungus *Verticillium albo-atrum*. The symptoms of this disease that are visible above ground cannot be easily differentiated from the symptoms of red stele and other root diseases. When the disease is not serious, an occasional plant will die, or several plants scattered over a patch may wilt down and die. When the disease is serious, the entire patch will

¹Other red stele resistant varieties are available. For a complete list of them, write to Department of Plant Pathology, University of Illinois, Urbana, Illinois 61801.

die out. *Verticillium* does not respond to drainage or elevation of the planting site as does red stele. There is no practical chemical control available for this disease. It is not wise to plant strawberries on land which has previously grown any of the solanaceous plants such as potato, tomato, and pepper. These are particularly susceptible to *Verticillium* wilt and the soil may become contaminated with wilt inoculum. This disease is well established in Illinois. Some varieties are more tolerant to *Verticillium* than others. For this information see Table 1, page 10.

Gray mold. This is one of the most common strawberry diseases. It is caused by a fungus known as *Botrytis cinerea*. The gray mold fungus spends the winter in old stalks or other vegetative debris either in the strawberry patch or along adjoining fence rows. As spring approaches and the first strawberry blossoms appear, the wind may disseminate thousands of spores over the strawberry bed. These spores will infect the stems, blossoms, and fruit. Yield is greatly cut if a high percentage of new blossoms become infected. As the name implies, the diseased plant tissue is covered with a light gray, fluffy mold which is composed of fungus growth (mycelium) containing the spores. These spores cause more disease.

As the berries mature, they become more susceptible to infection. During very rainy and humid seasons, gray mold may destroy the entire crop. Often the disease is not detected until berrypicking time, when a large number of rotten berries are found. Within 48 hours after the good berries are picked, they may become a mass of rotted fruits (Fig. 19).

For control, use the fungicides recommended on page 50.

Rhizopus rot. This fruit rot is caused by the fungus *Rhizopus stolonifer*. It is primarily a post-harvest disease which develops on the fruit after it is picked. The rot is commonly called "leak" since the juice from diseased berries leaks out of the bottom of the container. Because the organism is found on all types of fruit and vegetative debris, it may occur under field conditions when the weather is ideal for its development.

Rhizopus rot is characterized by the very soft, watery tissue at the surface of the fruit and the ready exudation of the juice on slight pressure. In packaged fruit this rot may be confused with gray mold since the entire surface of the package soon becomes covered with a white, fluffy mycelial mat. Black fruiting bodies may be seen scattered over the surface of this growth, and this distinguishes it from the gray mold disease.

Sanitation is one of the best means of keeping *Rhizopus* at a minimum. The fruit should be handled carefully to prevent bruises, and



Gray mold on strawberries. Note fuzzy covering of rotted fruit. (Fig. 19)

culls should not be allowed to accumulate. Precooling to 50° F. or lower helps control *Rhizopus*.

Minor fungus diseases. Other diseases are reported occasionally in Illinois. Cortical root rot has been reported and a species of *Rhizoctonia* has been considered one of the pathogens causing the damage. This is commonly referred to as a root rot complex since many pathogens have been found associated with this type of damage. Another disease known as leather rot, caused by the fungus *Phytophthora cactorum*, is commonly found in Illinois. Berries in close proximity with the soil may turn brown and appear water soaked. But instead of becoming soft, as happens with most fruit rots, the infected area becomes hard and leathery. This disease will attack fruits at all stages of maturity.

No control is known for either cortical root rot or for leather rot.

Powdery mildew is another minor disease that may become serious during high humidity, heavy dews, or misting, and moderately cool temperatures. This disease causes the edges of affected leaves to curl upward, exposing the undersurface. The powdery growth develops on all sides of the leaves and stem. A serious infection usually interferes with the maturation of the fruit. It is likely to be more prevalent in the northern third of the state.

If powdery mildew becomes a problem, use sulfur sprays or dusts. These may be combined with a regular chemical treatment or applied separately, whichever is more convenient. Dinocap may be used in place of sulfur.

Virus diseases. Several virus diseases are known to cause damage to strawberry plants. Such diseases may produce either leaf mottling, mild yellow-edge, crinkle, vein chlorosis, leaf curl, or dwarfing. As it is impossible to cure an established virus infection, all infected plants should be destroyed as soon as they are seen. Sucking insects such as aphids spread virus diseases from plant to plant. For this reason it is important to apply enough of some insecticide, such as either malathion or Endosulfan, to the plants during the growing season to keep these insects under control should they become prevalent.

All reliable nurseries now sell only substantially virus-free plants. Thus it is possible to make new plantings substantially free of virus and, for all practical purposes, to eliminate the virus problem. Of course, diseases can be brought in from wild strawberry or infected volunteer plants. For this reason it is still important to keep the insects under control.

Leaf variegation (spring yellows). Leaf variegation is currently considered to be a noninfectious disease attributed to a defect in the hereditary makeup of the plant. Many of the common varieties such as Blakemore, Howard 17 (Premier), Vermilion, and Dixieland have shown this condition. Symptoms may appear in the spring, disappear during warm weather, and then reappear in the fall or the following spring. The green of the new leaves becomes pale and lightly spotted or streaked with yellow. Each year it may become progressively worse until the plants become weak and stunted. There is no cure for this disease but it can be prevented by using non-variegated planting stocks. Always use virus-free plants and do not accept plants that show yellows symptoms.

Nematodes. Nematodes are microscopic wormlike creatures found not only in the soil but also in fresh and salt water. Some attack strawberry roots, others the above-ground parts. When nematodes occur in large numbers, they can seriously weaken the plants. Most of the root nematodes are more destructive in sandy soils than in clay soils. A recent survey of strawberry plantings in Illinois did not reveal any fields so heavily infested that soil fumigation was warranted.

PUBLICATIONS ON STRAWBERRY CULTURE

A number of books have been published that deal wholly or in part with strawberry culture. Among these are:

Fruit Science — Childers

Small Fruits for Your Home Garden — Clarke

Small Fruit Culture — Shoemaker

The Strawberry — Darrow

Other publications about strawberry growing include the following leaflets and circulars. Single copies are free except where noted.

Available from the Office of Information, U.S. Department of Agriculture, Washington, D.C. 20402:

Strawberry Varieties in the United States (Farmers' Bulletin 1043)

Preparing Strawberries for Market (Farmers' Bulletin 1560)

Strawberry Diseases (Farmers' Bulletin 2140)

Strawberry Insects (Farmers' Bulletin 2184)

Available from the Office of Publications, College of Agriculture, University of Illinois, Urbana, Illinois 61801:

Weeds of the North Central States (Circular 718; \$1.00)

Irrigation, Is It for You? (Circular 763)

Buying Your Sprinkler Irrigation System (Circular 789)

Band-Spraying Pre-Emergence Herbicides (Circular 791)

Calibrating and Maintaining Spray Equipment (Circular 837)

Calibrating and Adjusting Granular Row Applicators (Circular 839)

Soil Fumigation . . . Preventing Soil Pest Problems Before They Develop (Circular 869)

Growing Small Fruits in the Home Garden (Circular 935)

Available from the Department of Plant Pathology, University of Illinois:

Strawberry Red Stele Root Rot (Plant Disease No. 701)

Strawberry Leaf Spot Diseases (Plant Disease No. 702)

Gray Mold of Strawberries (Plant Disease No. 704)

Strawberries — Spray and Dust Guide (Fruit Leaflet No. 1)

Leaf Variegation in Strawberries (Plant Disease No. 706)

Available from the Department of Horticulture, University of Illinois:

Herbicides for Commercial Fruit Crops (H-659)

Sources of Small Fruit Plants (Fruit Growing No. 15)

Strawberry Varieties (Fruit Growing No. 16)

FOR YOUR PROTECTION

Always handle pesticides with respect. After all, the people most likely to suffer ill effects from pesticides are the applicator and his family. Accidents and careless, needless overexposure can be avoided by heeding the following suggestions for the safe use of pesticides.

1. Store pesticides out of reach of children, irresponsible persons, or animals; preferably store in a locked cabinet.
2. Put pesticide containers back in the storage area before applying pesticide. Children have found open bottles by the water tap.
3. Avoid breathing pesticide sprays and dusts over an extended period. This is particularly true in enclosed areas such as crawl spaces, closets, basements, and attics.
4. Wash with soap and water exposed parts of the body and clothes contaminated with pesticide.
5. Wear rubber gloves when handling pesticide concentrates.
6. Do not smoke while handling or using pesticides.
7. Do not blow out clogged nozzles with your mouth.
8. Leave unused pesticides in their original containers with the labels on them and in locked cabinets.
9. Wash out empty pesticide containers and then bury them, burn them, or haul them to the garbage dump.
10. Do not leave puddles of spray on impervious surfaces.
11. Do not apply pesticides to fish ponds.
12. Do not apply pesticides to dug wells or cisterns.
13. Observe all precautions listed on the label.